EURAMET DOSEtrace supplementary comparison in terms of the ambient dose equivalent/rate for photon radiation (EURAMET.RI(I)-S18)

Final report

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Abstract

A supplementary comparison in terms of the ambient dose equivalent/rate was organized within EURAMET as a part of the DOSEtrace project, between 13 national metrology institutes and designated institutes. Calibration coefficients were compared for a secondary standard ionisation chamber for 3 X-ray and 2 γ-ray radiation qualities used in the field of radiation protection. Radiation qualities were established according to ISO 4037-1. Measurements were performed between 2019 and 2021.

For the purpose of this comparison, it was considered that the reported uncertainty was confirmed if the relative deviation from the comparison reference value was smaller than or equal to the associated uncertainty. All the reported results by all the partners satisfied this criterium. Three participants were not able to perform calibrations in all mandatory radiation qualities, due to technical problems. The results are published in the Key Comparison Data Base (KCDB) of the BIPM as supplementary comparison EURAMET.RI(I)-S18.

Contents

1. Introduction

International Committee for Weights and Measures (CIPM) Mutual Recognition Arrangement (MRA) is a multilateral agreement between National Metrology Institutes (NMI) and Designated Institutes (DI). CIPM MRA provides mutual recognition of calibration and test certificates and national measurement standards. Key and supplementary comparisons are organized within the CIPM MRA framework to support member Calibration and Measurement Capabilities (CMC) [1].

Ambient dose equivalent, *H**(10), is an operational quantity used in ionizing radiation dosimetry for area monitoring. It was introduced by the ICRU [2] and adopted by the European Union in Council Directives 96/29/EURATOM and 2013/59/EURATOM. A EURAMET supplementary comparison of calibration coefficients for *H**(10) for photon radiation, EURAMET.RI(I)-S11, was organized between 2013 and 2014, with 16 NMIs and DIs and the International Atomic Energy Agency taking part [3]. There is still a need to organize follow-up comparisons for NMIs and DIs that still do not have published CMCs for *H**(10), and also to repeat comparisons regularly for the laboratories having CMCs.

The aim of this comparison was to compare calibration coefficients for *H**(10) for photon radiation. For this purpose, a transfer chamber was provided. The chamber was circulated between the partners, and was periodically returned to the pilot for stability checks. The comparison was performed for 5 radiation qualities (3 mandatory and 2 additional) which were established in accordance with ISO 4037-1 [4, 5]. During the comparison, the updated standard ISO 4037-1 was published, so some laboratories used the old version of the standard, and some laboratories the new version.

The radiation qualities chosen for the comparison were:

- N-40 (mandatory)
- N-100 (mandatory)
- N-200 (additional)
- S-Cs (mandatory)
- S-Co (additional)

The agreed dose rate range was between 0.5 mSv/h and 10 mSv/h. The recommended value was 6 mSv/h.

This comparison can be used to validate calibrations in terms of ambient dose equivalent/rate. Due to the similar calibration procedures, calibrations in terms of personal dose equivalent/rate, penetrating and superficial, can also be validated by this comparison.

This comparison is intended to validate calibrations in X-ray radiation qualities from 40 kV to 300 kV, as well as qualities S-Cs and S-Co. The comparison was performed for N-series X-ray radiation qualities, but calibrations in other standard qualities established in accordance with ISO 4037-1 [5] (H-series, W-series, L-series) use similar procedures, so the comparison can be appropriate for validation of these additional radiation qualities.

The comparison was organized within the technical Work Package 2 of the 17RPT01 DOSEtrace project, a research potential project from the 2017 EURAMET EMPIR call [6]. The comparison was coordinated by VINS as the pilot laboratory. PTB provided expertise in comparison organization and provided the transfer chamber. Other project partners supported the organization of this comparison and the drafting of this report.

This comparison protocol was prepared according to EURAMET guidelines [7].

2. Participants

Thirteen NMIs and DIs took part in the comparison:

- VINS – Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia
- GUM – Central Office of Measures/Glowny Urzad Miar, Poland
- HMI/IRB-SSDL – Secondary Standard Dosimetry Laboratory of the Ruđer Boskovic Institute, Croatia
- IMBiH – Institute of Metrology of Bosnia and Herzegovina, Bosnia and Herzegovina
- INM-MD – National Institute of Metrology of the Republic of Moldova, Moldova
- IRCL/GAEC-EIM – Ionizing Calibration Laboratory/Greek Atomic Commission - Helenic Institute of Metrology, Greece
- IST-LPSR-LMRI – Instituto Superior Técnico, Portugal
- MIRS/IJS/F-2,O-2 – Metrology Institute of the Republic of Slovenia/Jozef Stefan Institute/Low and Medium Energy Physics F2, Environmental Sciences O2, Slovenia
- NSC-IM – National Scientific Centre “Institute of Metrology”, Ukraine
- PTB – Physikalisch-Technische Bundesanstalt, Germany
- SCK • CEN/LNK – Studiecentrum voor Kernenergie, Centre d'Étude de l'énergie Nucléaire / The Laboratory for Nuclear Calibrations, Belgium
- SMU – Slovak Institute of Metrology, Slovakia
- TENMAK-NÜKEN – Turkish Energy, Nuclear And Mineral Research Agency – Nuclear Energy Research Center (former TAEK), Turkey

3. Transfer standard

A secondary standard ionisation chamber Seibersdorf HS01 [8] S/N 112 was used as the transfer standard. The chamber is shown in Figure 1. The chamber is of spherical shape and has a nominal volume of 1 l. The outer diameter of the chamber is 140 mm. The chamber voltage should be set to +300 V and applied to the collecting electrode (inner electrode).

The chamber has BNC connector for current measurement and Lemo connector for the high voltage (HV) supply. An adapter with a Lemo (FFA.1S.304.CLAC52) connector to a banana plug (4 mm pin plug) is used for HV. Connectors and adapters are shown in Figure 2. An adapter to TNC connector was provided as well.

Figure 1: HS01 S/N 112, Secondary standard chamber for *H*(10)* (Photo credit Bildstelle PTB)

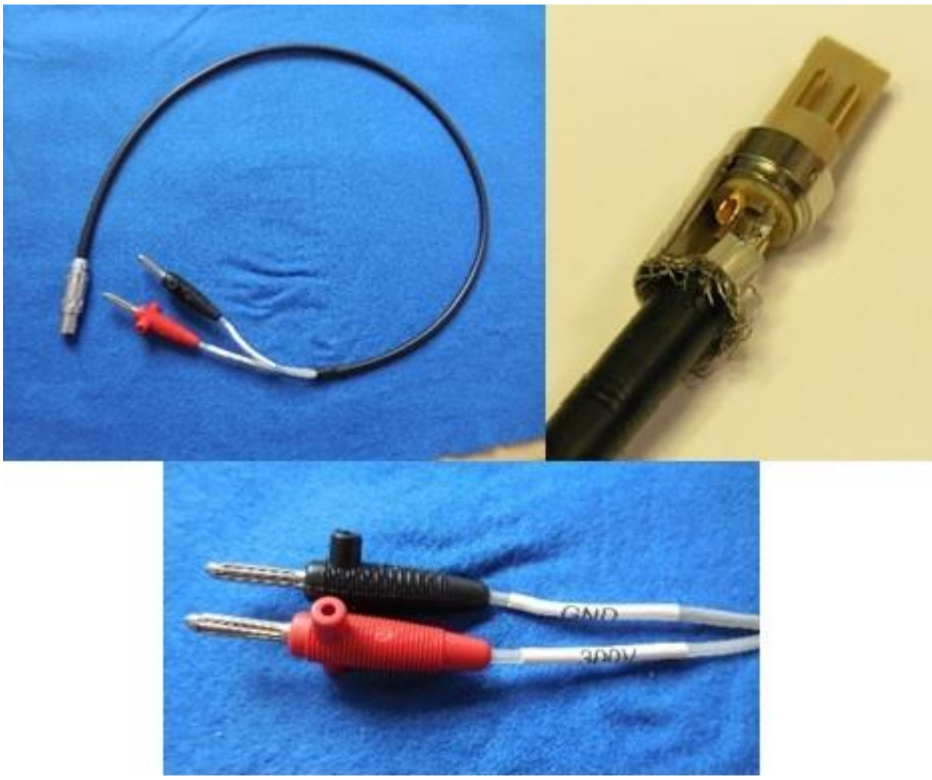

Figure 2: Cable for high voltage connection and details of the connectors

4. Linearity of the transfer chamber

Due to the fact that it was not possible to determine a dose rate that can be realized by all the participants, the pilot laboratory performed a linearity test with respect to dose rate before the start of the official part of the comparison. The linearity test was performed in N-100 radiation quality. The test included the whole agreed range of dose rates – with ambient dose equivalent rates between 0.5 mSv/h and 10 mSv/h. The results of the linearity test are shown in Figure 3

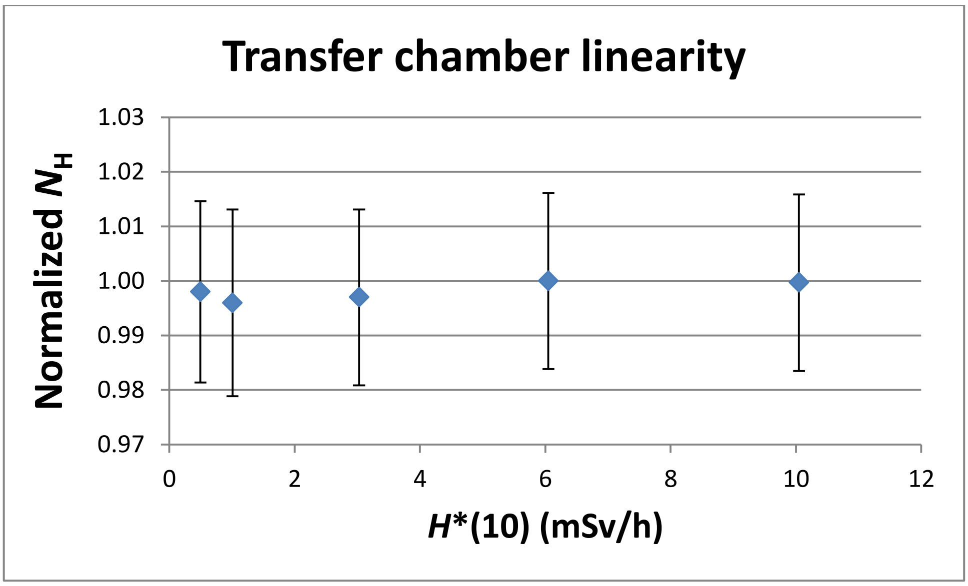

Figure 3: Transfer chamber linearity.

Calibration factors were normalized to the value for 6 mSv/h (recommended dose rate). Maximum deviation of the ratio from unity is 0.4 %. The measurement uncertainty for the normalized values was considered taking into account correlations – the measurement uncertainty of the calibration factor of the secondary standard, the radiation quality and the conversion coefficient were excluded from the budget. The remaining uncertainty is around 1.7 % and is due to the working standard stability and linearity, repeatability of the setup, changes of temperature and pressure, and repeatability of readings. Considering that the measured non-linearity is much smaller than the measurement uncertainty for all dose rates, the correction for non-linearity was not performed.
The conclusion of the linearity test is that over the tested range of dose rates, the effect of changes in ion recombination can be neglected
During the comparison, some participants were not able to achieve dose rates within the recommended range for some radiation qualities. These results are marked in Tables 5 to 9, but are not corrected. Due to the excellent linearity of the ionisation chamber, any influence on the calibration factor due to dose rate is expected to be small, even outside the investigated range.

5. Stability of the transfer chamber

Stability of the transfer chamber was checked by performing periodical calibrations in all radiation qualities by VINS. The first calibration was performed at the beginning of the comparison, and the last after all participants had finished the calibrations. Two additional calibrations were performed in-between the other partner's calibrations. The stability checks were used to enlarge the measurement uncertainty, as described in section 8.

6. Tests and procedures that were carried out before measurements

The transfer standard was used with the electrometers provided by the participants. The following advice was given to the participants: "The measurement system should be left in the measurement room to reach thermal equilibrium, preferably overnight. The transport container should be left closed during this process, especially in cold weather. The transfer chamber should be used according to the installation instructions provided inside the transport container. The electrometer has to be switched on at least one hour before measurements and the chamber should be used with a collecting voltage of +300 V applied to the collecting electrode (inner electrode). Even though pre-irradiation of this chamber is not necessary, pre-irradiation for at least 10 minutes is recommended. Before measurements, the measurement system should be zeroed and at least 10 leakage measurements taken to ensure that the leakage current is less than 0.1 % of the anticipated signal."

7. Calibration method, calibration conditions

The comparison of calibration coefficients was performed for three mandatory radiation qualities and two additional radiation qualities. The mandatory radiation qualities were N-40, N-100 and S-Cs. Additional radiation qualities were N-200 and S-Co. All radiation qualities were realised in accordance with ISO 4037-1 [4, 5]. Three laboratories were not able to perform calibrations in some of the mandatory radiation qualities, due to technical problems: IRB and SMU in N-40 and N-100, and INM-MD in N-40.

Most participants performed reference measurements in terms of air kerma free-in-air, and used conversion coefficients from ISO 4037-3 [9, 10]. PTB used spectrometry to determine conversion coefficients. GAEC performed reference measurements in terms of ambient dose equivalent for radiation qualities N-100, N-200 and S-Cs, so conversion coefficients were not used. Table 1 gives an overview of the methods used to establish X-ray fields for participants that used the new version of ISO 4037 (characterized versus matched fields).

It should be noted that all parts of the ISO 4037 standard were updated during the comparison, meaning that some participants used the old version of the standard, and some participants used the new version. An overview is given in Table 1. Considering the realization of the reference fields, there are some significant changes for the X-ray radiation qualities, e.g. regarding the distinction between characterized and matched radiation fields, requirements for X-ray units etc. Changes for radionuclide radiation qualities are much smaller. A detailed list of changes can be seen in the standard documents [4, 5]. The most significant change is in the recommended value of the conversion coefficients for radiation qualities N-40 and S-Cs. However, the change is significantly smaller than the uncertainty of the conversion coefficient [9, 10]. This change does not affect laboratories that perform spectrometry, and the laboratories with standards traceable in terms of $H^*(10)$ to laboratories that perform spectrometry. The results are reported as received from the participants, and no corrections for the use of different versions of the standard are performed. The changes due to the new procedures were expected to be smaller than the expanded measurement uncertainty, and not to affect the overall conclusion of the comparison. In addition, values of conversion coefficients used by each individual partner for each radiation quality are reported in Tables 5 to 9, for future reference.

Table 1: Overview of the version of ISO 4037 used by participants and the type of X-ray reference fields

Participant	Version of ISO 4037	Type of X-ray fields
VINS	Old	N/A
PTB	New	Characterized by spectrometry
HMI/IRB-SSDL	Old	N/A
MIRS/IJS/F-2,O-2	Old	N/A
SMU	Old	N/A
IRCL/GAEC-EIM	New	Characterized by dosimetry (except for N-40)
SCK • CEN/LNK	New	Matched
GUM	New	Matched
IST-LPSR-LMRI	Old	N/A
IMBiH	New	Matched
TENMAK-NÜKEN	New	Matched
INM MD	New	Matched
NSC-IM	Old	N/A

In the reference orientation of the chamber, the Type number and S/N are pointed towards the radiation source. The reference point is the geometrical centre of the sensitive volume of the chamber. The air-kerma rate at the point of test should not vary by more than 5 % over the entire sensitive volume of the transfer chamber. The chamber must be irradiated completely. Chamber readings were corrected for air density (reference conditions: air pressure 101.325 kPa, ambient temperature 20.0 °C, relative air humidity 65 %). Leakage current correction must be performed if leakage is higher than 0.1 % of the signal. Participants may perform additional corrections, according to their own procedures. Correction for polarity effects was not necessary, because the transfer chamber was used with a unique configuration for the polarity and voltage.

The calibration coefficient in Sv/C is given by

$$N_{\mathrm{H}} = \frac{H*(10)}{Q_{cor}}$$

where $H*(10)$ is the conventional true value of ambient dose equivalent and Q_{cor} the collected charge for transfer standard measurements, corrected to the reference conditions.

The measurement results and uncertainty budgets were reported in the Excel form provided by VINS (see Annex A and Annex B). The uncertainty was determined in accordance with the BIPM Guide to the expression of uncertainties in measurements [11].

8. Calculation of the Comparison Reference Value and evaluation of the comparison results

The comparison reference value, *CRV,* was determined for each radiation quality as the weighted mean of the calibration coefficients, $N_{H,}$ reported by the primary standards laboratories – participants which have traceability to their own primary standards for K_a or $H^*(10)$ – PTB and GUM for all radiation qualities, and SMU for S-Cs and S-Co.
The *CRV* was calculated according to equation 1:

$$CRV = \frac{\sum_{i=1}^{n} \frac{N_{Hi}}{u_i^2}}{\sum_{i=1}^{n} \frac{1}{u_i^2}} \qquad (1)$$

where n is the number of laboratories with calibrations traceable to their own primary standard, N_{Hi} is the i-th calibration coefficient and u_i is the uncertainty of the i-th calibration coefficient [7, 12].
The uncertainty of the *CRV*, $u(CRV)$ is calculated according to equation 2:

$$u^2(CRV) = \left(\sum_{i=1}^{n} \frac{1}{u_i^2} \right)^{-1} \qquad (2)$$

The Degrees of Equivalence with the comparison reference value were evaluated by calculating the deviation from the comparison reference value (d_i) and expanded uncertainty of that deviation. The deviation was calculated by applying the formula $d_i = N_{Hi} - CRV$. Having in mind that individual calibration coefficients were compared to the *CRV*, and that the *CRV* was calculated based on the calibration coefficients provided by primary standards laboratories, correlations between primary standards laboratories and the *CRV* need to be taken into account. In case that a laboratory contributes to the *CRV*, covariance is evaluated in the way described by M.G. Cox [12], finally yielding the equation $u(d_i)^2 = u_i^2 - u(CRV)^2$. The derivation of the equation can be found in reference [12]. In this comparison, uncertainty due to the stability of the transfer chamber, evaluated as the standard deviation of 4 calibrations performed in VINS (u_{stab}), is added to the uncertainty.

In case of primary standards laboratories, the uncertainty of d_i is calculated according to equation 3:

$$u(d_i)^2 = u_i^2 - u(CRV)^2 + u^2_{stab} \qquad (3)$$

In case of laboratories with secondary standards, any possible correlations are disregarded, and $u(d_i)$ is evaluated according to equation 4:

$$u(d_i)^2 = u_i^2 + u(CRV)^2 + u^2_{stab} \qquad (4).$$

Finally, for the presentation of the results, relative deviation and associated uncertainty were used, denoted as $D_i = 100 \cdot d_i / CRV$ and $u(D_i) = 100 \cdot u(d_i) / CRV$.

Correlations between secondary standards laboratories and the *CRV* were not evaluated. Even though many laboratories use the same values of the conversion coefficients, this does not cause correlations, because each laboratory has different realizations of the standard radiation qualities, with different “true” values of conversion coefficients. Therefore, the differences between the true values of the conversion coefficients and recommended values of the conversion coefficients are randomly distributed. Conversion coefficients for mono-energetic radiation are considered as having no uncertainty [10].

Regarding the traceability for air kerma, several secondary standards laboratories are traceable to PTB, either directly or through IAEA. In most cases, contribution of the uncertainty of the calibration coefficient of the reference standard to the uncertainty of the calibration coefficient of the transfer instrument is very small, because of the high uncertainty in the conversion coefficient. In most cases, this contribution is below 10%, as can be calculated from the data in Annex A.

Finally, participant IRCL/GAEC-EIM is traceable to PTB in terms of $H^*(10)$ for three radiation qualities. Correlation is very difficult to estimate in this case, because the chamber is calibrated in PTB, and used in IRCL/GAEC-EIM, in different realizations of the reference radiation qualities, with different true values of the conversion coefficients. In addition, the secondary standard used by IRCL/GAEC-EIM has significant energy dependence in terms of $H^*(10)$. The correlation is likely to be of the same order as for the other laboratories, considering that the only definite common source of uncertainty is the traceability to the same primary standard of air kerma.

Traceability for each participant is given in Table 2.

Table 2: Traceability, as reported by participants

Participant	Traceability - in terms of K_a unless otherwise stated				
	N-40	N-100	N-200	S-Cs	S-Co
VINS	PTB through IAEA	PTB through IAEA	PTB through IAEA	BIPM through IAEA	BIPM through IAEA
PTB	PTB	PTB	PTB	PTB	PTB
HMI/IRB-SSDL	/	/	/	BIPM through IAEA	BIPM through IAEA
MIRS/IJS/F-2,O-2	BFKH (MKEH)	BFKH (MKEH)	/	BFKH (MKEH)	/
SMU	/	/	/	SMU	SMU
IRCL/GAEC-EIM	PTB	PTB (in terms of $H^*(10)$)	PTB (in terms of $H^*(10)$)	PTB (in terms of $H^*(10)$)	/
SCK • CEN/LNK	PTB	PTB	PTB	PTB	PTB
GUM	GUM	GUM	GUM	GUM	GUM
IST-LPSR-LMRI	PTB	PTB	PTB	IST-LPSR-LMRI	/
IMBiH	PTB through IAEA	PTB through IAEA	PTB through IAEA	BIPM through IAEA	/
TENMAK-NÜKEN	PTB	PTB	PTB	PTB	PTB
INM MD	/	PTB through IAEA	PTB through IAEA	BIPM through IAEA	/
NSC-IM	PTB through IAEA	PTB through IAEA	PTB through IAEA	BIPM through IAEA	BIPM through IAEA

9. Organisation and time schedule

In total, 13 NMIs and DIs participated in the comparison. The comparison started in VINS in February 2019. Before the first calibration, VINS performed a dose rate dependence test. Other participants were divided in 3 blocks and each had 1 month to receive the transfer chamber, perform the comparison and ship the chamber to the next participant. After each block, the transfer chamber was planned to be returned to VINS for stability check. Two months were planned for each stability check in order to compensate for any delays by other partners. Additionally, 4 months at the end of the schedule were planned for any unpredicted delays.
The original comparison time schedule is shown in Table 3.

Table 3: Planned time schedule

Feb	19	VINS
Mar	19	PTB
Apr	19	HMI/IRB-SSDL
May	19	MIRS/IJS/F-2,O-2
Jun	19	SMU
Jul	19	VINS – quality check
Aug	19	
Sep	19	IRCL/GAEC-EIM
Oct	19	GUM
Nov	19	SCK • CEN/LNK
Dec	19	IST-LPSR-LMRI
Jan	20	VINS – quality check
Feb	20	
Mar	20	IMBiH
Apr	20	TENMAK-NÜKEN
May	20	INM-MD
Jun	20	NSC-IM
Jul	20	VINS – quality check
Aug	20	
Sep	20	
Oct	20	
Nov	20	
Dec	20	

During the comparison, there were significant delays due to two reasons. In 2020, the comparison was completely halted for almost 6 months due to the onset of the COVID-19 pandemic. After the comparison was continued, there were still delays related to COVID-19, due to staff shortages, work from home, changed working hours, limited laboratory access and shipping delays. The second cause of delay was the malfunction of the adapter cable, which caused an additional delay of almost 6 months. Stability checks were performed before and after the malfunction and didn't show any significant influence of the adapter cable. The actual schedule of measurements is shown in Table 4.

Table 4: Actual time schedule

Feb 19	VINS
Mar 19 – Apr 19	PTB
Apr 19 – May 19	HMI/IRB-SSDL
May 19 – Jun 19	MIRS/IJS/F-2,O-2
Jul 19 – Aug 19	SMU
Aug 19 – Sep 19	VINS – quality check
Sep 19 – Nov 19	IRCL/GAEC-EIM
Dec 19	SCK • CEN/LNK
Dec 19 – Jan 20	GUM
Jan 20 – Mar 20	IST-LPSR-LMRI
Jul 20 – Aug 20	VINS – quality check
Sep 20 – Oct 20	IMBiH
Oct 20 – Apr 21	TENMAK-NÜKEN
Apr 21 – May 21	INM-MD
May 21 – Jul 21	NSC-IM
Jul 21	VINS – quality check

Note: In 2021, SCK • CEN/LNK commissioned a new laboratory building. The Xstrahl dual tube X-ray generator was just moved to the new building, without any other change. A new horizontal irradiator for S-Cs and S-Co was installed and the previous Canberra type irradiator was decommissioned. All Cs-137 and Co-60 sources were re-used in the new irradiator. All reference instruments were preserved and the same measurement procedures were kept at the new facility. A detailed re-validation of the X-ray generator was done at the new building and no significant changes were observed. During this comparison SCK • CEN/LNK performed all measurements at the old KAL building.

10. Results for radiation quality N-40 (mandatory)

Results of the intercomparisons for N-40 radiation quality are presented in Table 5 (primary standards laboratories are written in bold italic text). All uncertainties in the table are expanded uncertainties, with coverage factor k = 2. For the purpose of this comparison, **it is considered that the uncertainty reported by the participant is confirmed if the following is true: $|D_i| \leq U(D_i)$.**
Graphic representation of the results is given in Figure 4. In this case, if the uncertainty bar for a specific result crosses the X-axis, the uncertainty reported by the relevant participant is considered confirmed.
This radiation quality was mandatory, but three participants were not able to perform calibrations, due to technical problems with their X-ray systems.

CRV = (26.23 ± 0.64) µSv/nC (k = 2)
U_{stab} = 0.094 µSv/nC (k = 2)

Table 5: Results of the comparison in N-40 radiation quality (all uncertainties are reported with k = 2)

Participant	N_H (µSv/nC)			$H^*(10)$ (mSv/h)	h_k (Sv/Gy)	D_i (%)	$U(D_i)$ (%)
VINS	26.34	±	1.16	6.15	1.18	0.43	5.07
PTB	26.19	±	0.80	5.98	1.197	-0.15	1.84
HMI/IRB-SSDL							
MIRS/IJS/F-2,O-2	26.01	±	1.20	6.60	1.18	-0.83	5.21
SMU							
IRCL/GAEC-EIM	26.38	±	1.23	6.43	1.20	0.58	5.31
SCK • CEN/LNK	26.76	±	1.14	6.14	1.20	2.03	5.01
GUM	26.30	±	1.09	5.88	1.197	0.27	3.37
IST-LPSR-LMRI	26.25	±	1.06	1.31	1.18	0.08	4.74
IMBiH	26.69	±	1.19	6.17	1.20	1.76	5.17
TENMAK-NÜKEN	26.00	±	1.45	6.01	1.20	-0.87	6.06
INM MD							
NSC-IM	26.59	±	1.36	37.25*	1.18	1.38	5.75

*This dose rate value is outside of the agreed range (see section 4 Linearity of the transfer chamber)

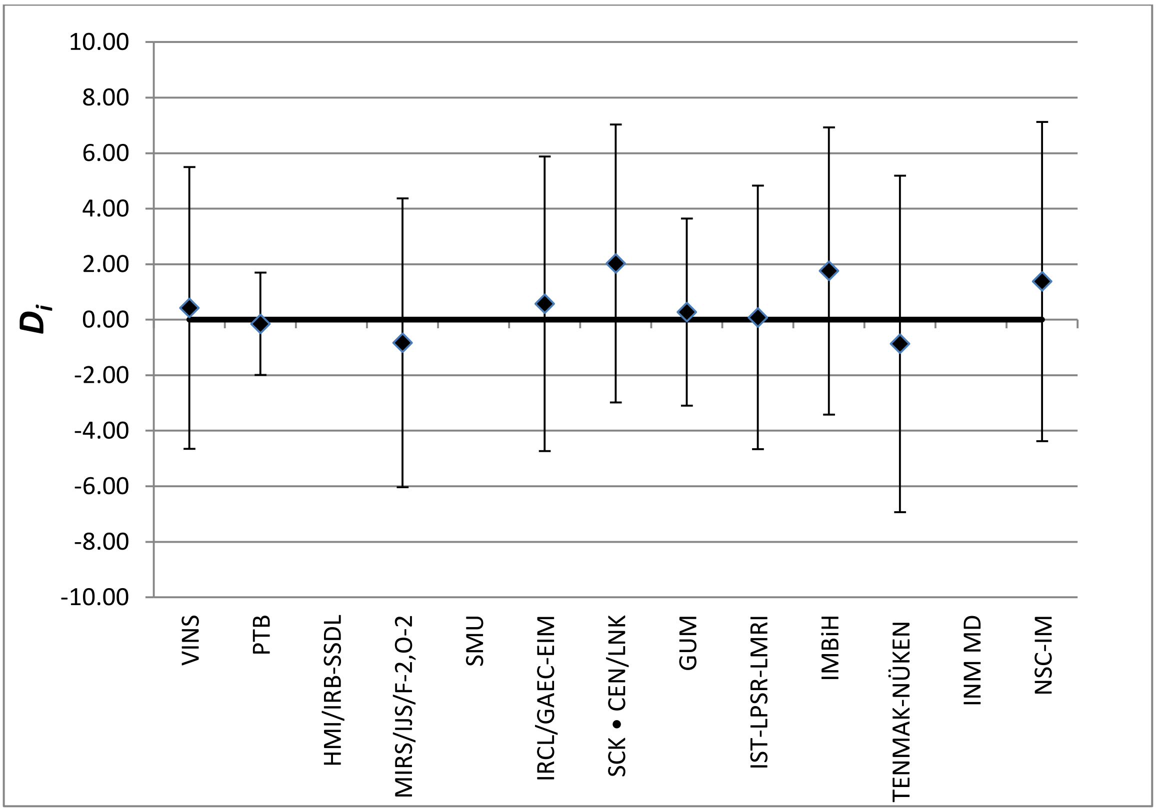

Figure 4: Relative degrees of equivalence for radiation quality N-40

All the results of the comparison in radiation quality N-40 are consistent within the reported measurement uncertainty.

11. Results for radiation quality N-100 (mandatory)

Results of the intercomparisons for N-100 radiation quality are presented in Table 6 (primary standards laboratories are written in bold italic text). All uncertainties in the table are expanded uncertainties, with coverage factor k = 2. For the purpose of this comparison, **it is considered that the uncertainty reported by the participant is confirmed if the following is true: $|D_i| \leq U(D_i)$.**
Graphic representation of the results is given in Figure 5. In this case, if the uncertainty bar for a specific result crosses the X-axis, the uncertainty reported by the relevant participant is considered confirmed.

This radiation quality was mandatory, but two participants were not able to perform calibrations, due to technical problems with their X-ray systems.

CRV = (29.12 ± 0.72) µSv/nC (k = 2)
U_{stab} = 0.21 µSv/nC (k = 2)

Table 6: Results of the comparison in N-100 radiation quality (all uncertainties are reported with k = 2)

Participant	N_H (µSv/nC)			$H^*(10)$ (mSv/h)	h_k (Sv/Gy)	D_i (%)	$U(D_i)$ (%)
VINS	29.66	±	1.30	6.11	1.71	1.84	5.15
PTB	29.31	±	0.90	5.99	1.707	0.64	1.98
HMI/IRB-SSDL		±					
MIRS/IJS/F-2,O-2	29.05	±	1.34	7.20	1.71	-0.25	5.27
SMU		±					
IRCL/GAEC-EIM	29.37	±	1.35	6.93	/	0.85	5.30
SCK • CEN/LNK	29.84	±	1.27	5.81	1.71	2.46	5.06
GUM	28.79	±	1.20	5.71	1.710	-1.14	3.37
IST-LPSR-LMRI	30.00	±	1.22	0.99	1.71	3.01	4.92
IMBiH	29.19	±	1.29	5.90	1.71	0.23	5.12
TENMAK-NÜKEN	28.84	±	1.27	5.96	1.71	-0.97	5.06
INM MD	28.62	±	1.40	6.58	1.71	-1.73	5.45
NSC-IM	30.20	±	1.53	9.77	1.71	3.70	5.85

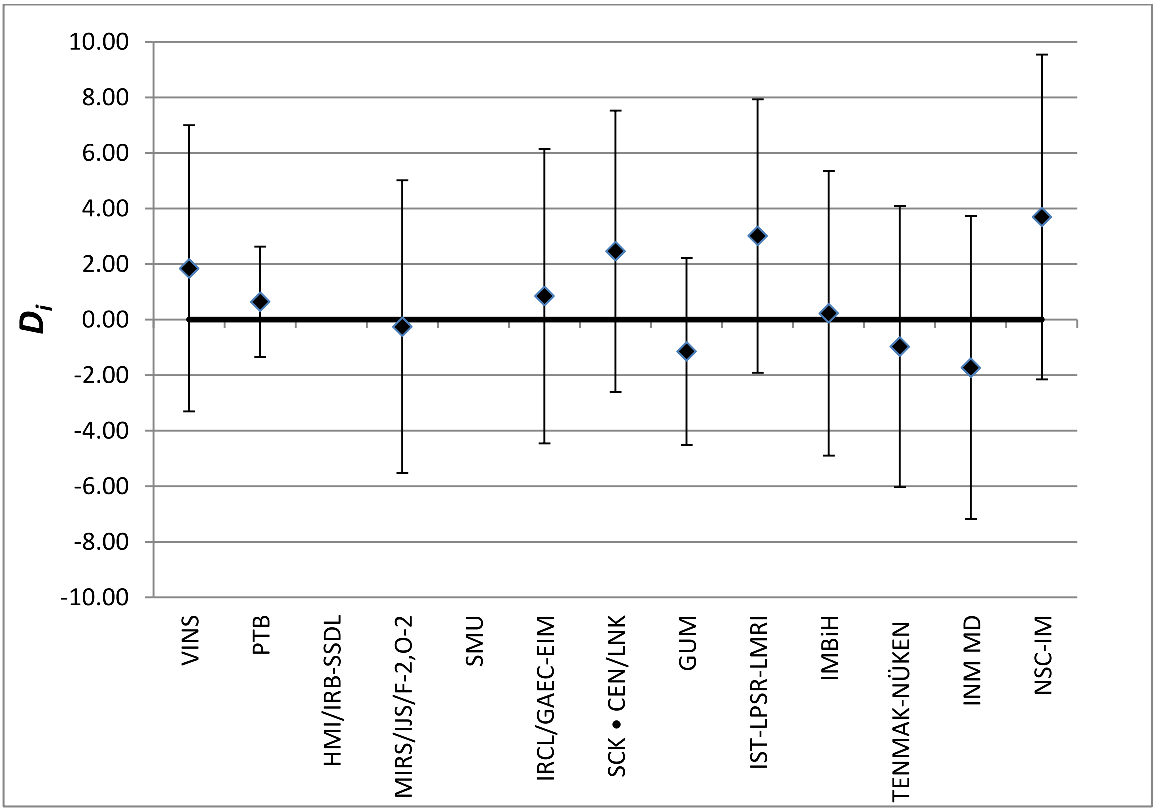

Figure 5: Relative degrees of equivalence for radiation quality N-100

All the results of the comparison in radiation quality N-100 are consistent within the reported measurement uncertainty.

12. Results for radiation quality N-200

Results of the intercomparisons for N-200 radiation quality are presented in Table 7 (primary standards laboratories are written in bold italic text). All uncertainties in the table are expanded uncertainties, with coverage factor k = 2. For the purpose of this comparison, **it is considered that the uncertainty reported by the participant is confirmed if the following is true: $|D_i| \leq U(D_i)$.**
Graphic representation of the results is given in Figure 6. In this case, if the uncertainty bar for a specific result crosses the X-axis, the uncertainty reported by the relevant participant is considered confirmed.

CRV = (29.35 ± 0.72) µSv/nC (k = 2)
U_{stab} = 0.19 µSv/nC (k = 2)

Table 7: Results of the comparison in N-200 radiation quality (all uncertainties are reported with k = 2)

Participant	N_H (µSv/nC)			$H^*(10)$ (mSv/h)	h_k (Sv/Gy)	D_i (%)	$U(D_i)$ (%)
VINS	29.95	±	1.32	6.02	1.46	2.03	5.16
PTB	29.34	±	0.90	5.97	1.46	-0.05	1.93
HMI/IRB-SSDL		±					
MIRS/IJS/F-2,O-2		±					
SMU		±					
IRCL/GAEC-EIM	29.12	±	1.34	6.64	/	-0.80	5.22
SCK • CEN/LNK	29.79	±	1.27	5.60	1.46	1.48	5.02
GUM	29.38	±	1.21	5.85	1.460	0.09	3.37
IST-LPSR-LMRI	29.74	±	1.21	1.30	1.46	1.31	4.84
IMBiH	29.20	±	1.29	6.04	1.46	-0.53	5.08
TENMAK-NÜKEN	29.52	±	1.30	5.95	1.46	0.56	5.10
INM MD	29.63	±	1.45	6.23	1.46	0.94	5.55
NSC-IM	30.35	±	1.54	13.37*	1.46	3.39	5.83

*This dose rate value is outside of the agreed range (see section 4 Linearity of the transfer chamber)

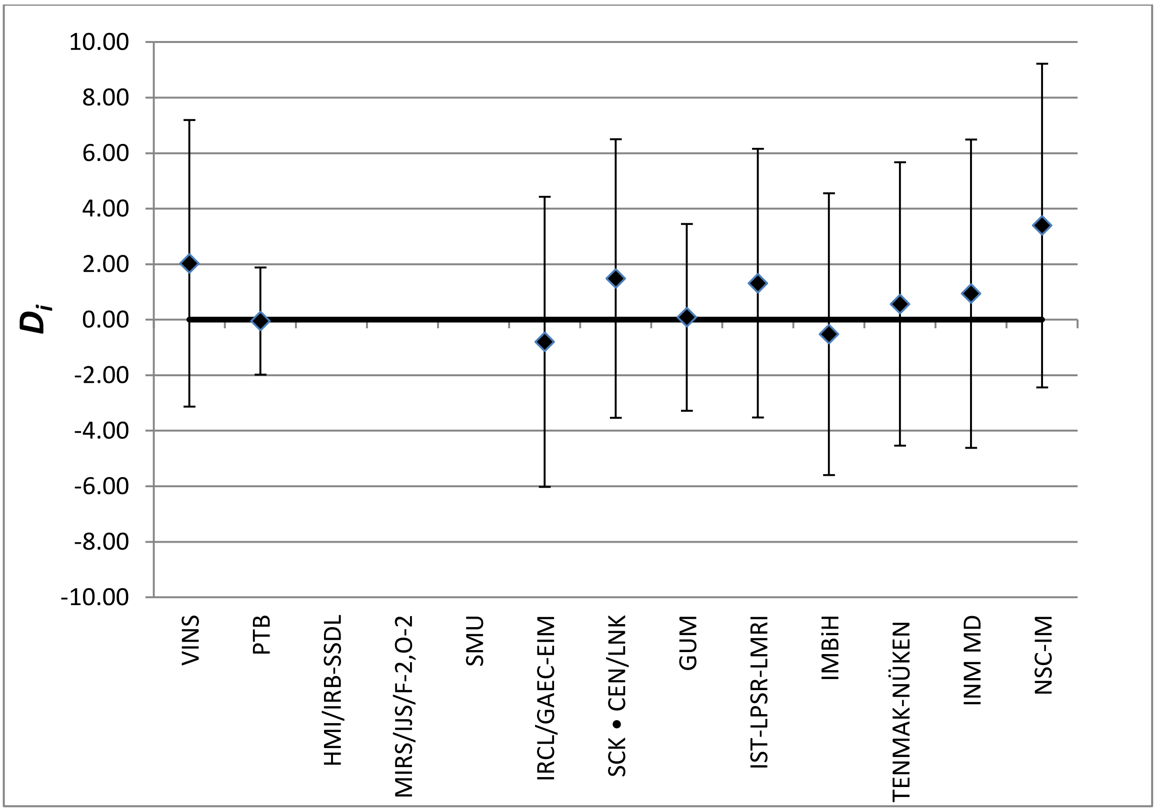

Figure 6: Relative degrees of equivalence for radiation quality N-200

All the results of the comparison in radiation quality N-200 are consistent within the reported measurement uncertainty.

13. Results for radiation quality S-Cs (mandatory)

Results of the intercomparisons for S-Cs radiation quality are presented in Table 8 (primary standards laboratories are written in bold italic text). All uncertainties in the table are expanded uncertainties, with coverage factor k = 2. For the purpose of this comparison, **it is considered that the uncertainty reported by the participant is confirmed if the following is true: $|D_i| \leq U(D_i)$.**
Graphic representation of the results is given in Figure 7. In this case, if the uncertainty bar for a specific result crosses the X-axis, the uncertainty reported by the relevant participant is considered confirmed.

CRV = (29.72 ± 0.61) µSv/nC (k = 2)
U_{stab} = 0.29 µSv/nC (k = 2)

Table 8: Results of the comparison in S-Cs radiation quality (all uncertainties are reported with k = 2)

Participant	N_H (µSv/nC)			$H^*(10)$ (mSv/h)	h_k (Sv/Gy)	D_i (%)	$U(D_i)$ (%)
VINS	29.46	±	1.26	0.63	1.20	-0.87	4.81
PTB	29.99	±	0.85	5.95	1.210	0.91	2.22
HMI/IRB-SSDL	29.04	±	1.54	5.27	1.200	-2.29	5.66
MIRS/IJS/F-2,O-2	29.53	±	1.29	7.40	1.20	-0.64	4.90
SMU	29.24	±	1.22	6.44	1.20	-1.62	3.69
IRCL/GAEC-EIM	30.08	±	1.09	6.17	/	1.21	4.31
SCK • CEN/LNK	30.03	±	1.28	6.18	1.21	1.04	4.87
GUM	29.64	±	1.25	6.01	1.210	-0.27	3.80
IST-LPSR-LMRI	29.64	±	1.24	0.80	1.20	-0.27	4.75
IMBiH	29.46	±	1.25	5.57	1.21	-0.87	4.78
TENMAK-NÜKEN	29.84	±	1.34	6.01	1.21	0.40	5.05
INM MD	29.51	±	1.33	4.49	1.21	-0.71	5.02
NSC-IM	29.59	±	1.22	15.44*	1.20	-0.44	4.69

*This dose rate value is outside of the agreed range (see section 4 Linearity of the transfer chamber)

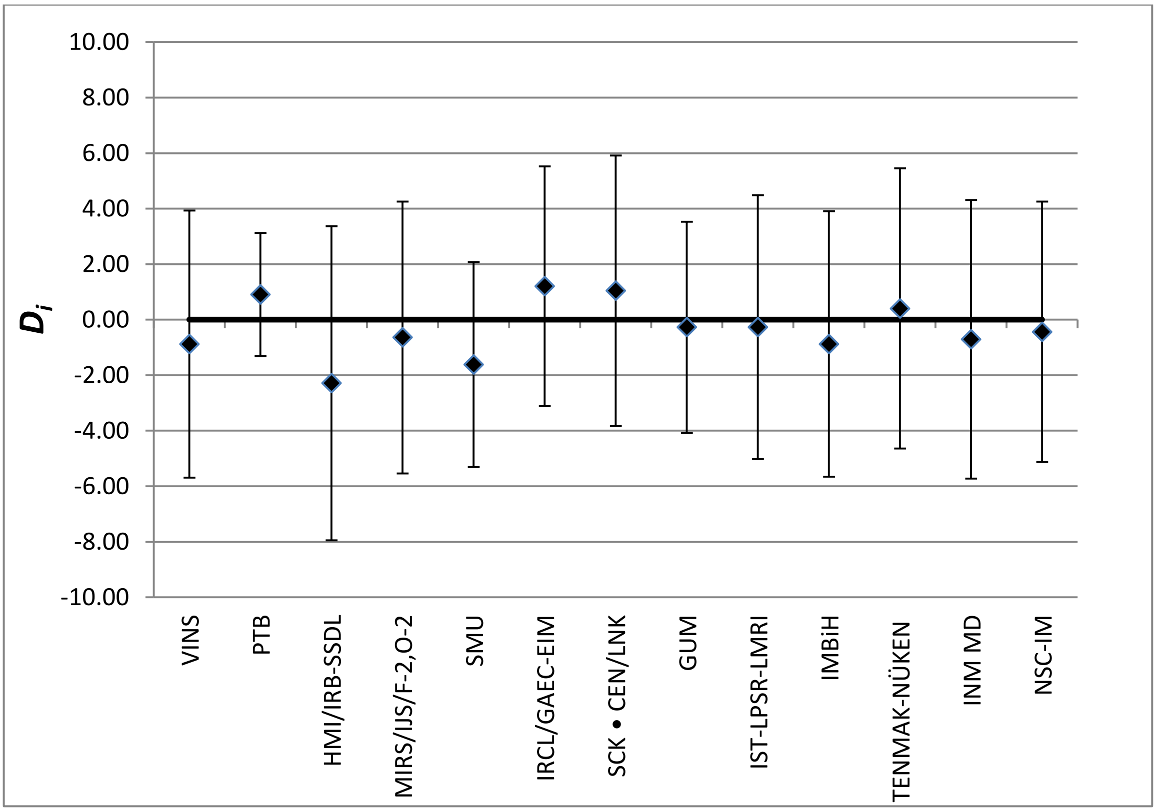

Figure 7: Relative degrees of equivalence for radiation quality S-Cs

All the results of the comparison in radiation quality S-Cs are consistent within the reported measurement uncertainty.

14. Results for radiation quality S-Co

Results of the intercomparisons for S-Co radiation quality are presented in Table 9 (primary standards laboratories are written in bold italic text). All uncertainties in the table are expanded uncertainties, with coverage factor k = 2. For the purpose of this comparison, **it is considered that the uncertainty reported by the participant is confirmed if the following is true: $|D_i| \leq U(D_i)$.**
Graphic representation of the results is given in Figure 8. In this case, if the uncertainty bar for a specific result crosses the X-axis, the uncertainty reported by the relevant participant is considered confirmed.

CRV = (28.55 ± 0.62) µSv/nC (k = 2)
U_{stab} = 0.028 µSv/nC (k = 2)

Table 9: Results of the comparison in S-Co radiation quality (all uncertainties are reported with k = 2)

Participant	N_H (µSv/nC)			$H^*(10)$ (mSv/h)	h_k (Sv/Gy)	D_i (%)	$U(D_i)$ (%)
VINS	28.26	±	1.20	2.03	1.16	-1.00	4.74
PTB	28.62	±	0.82	5.95	1.160	0.26	1.87
HMI/IRB-SSDL	28.53	±	1.51	9.27	1.160	-0.05	5.72
MIRS/IJS/F-2,O-2		±					
SMU	28.24	±	1.63	376.00*	1.16	-1.07	5.28
IRCL/GAEC-EIM		±					
SCK • CEN/LNK	28.36	±	1.21	6.05	1.16	-0.65	4.77
GUM	28.55	±	1.19	6.10	1.160	0.02	3.55
IST-LPSR-LMRI		±					
IMBiH		±					
TENMAK-NÜKEN	28.69	±	1.27	5.73	1.16	0.51	4.96
INM MD		±					
NSC-IM	29.01	±	1.21	0.69	1.16	1.63	4.77

*This dose rate value is outside of the agreed range (see section 4 Linearity of the transfer chamber)

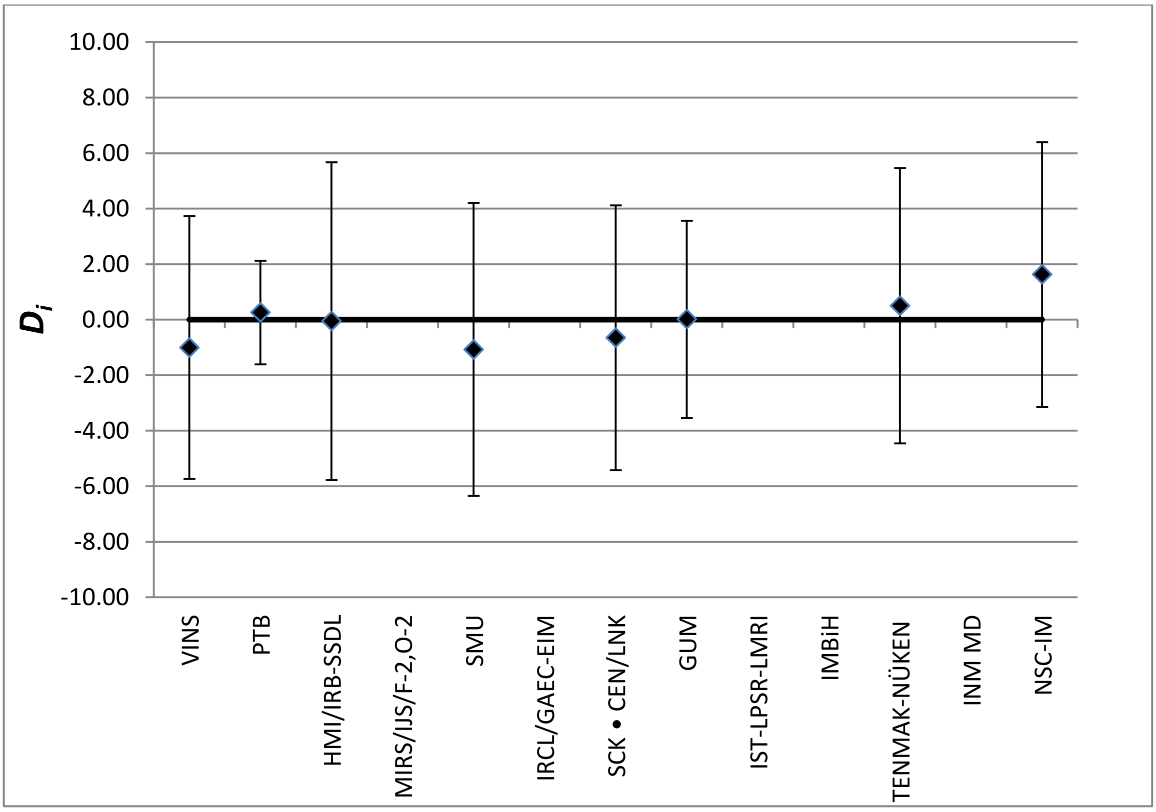

Figure 8: Relative degrees of equivalence for radiation quality S-Co

All the results of the comparison in radiation quality S-Co are consistent within the reported measurement uncertainty.

15. Conclusion

The EURAMET DOSEtrace supplementary comparison was completed successfully in terms of ambient dose equivalent, $H^*(10)$. All the reported results are consistent within the reported uncertainties. The measurements were completed for the radiation qualities N-40, N-100, N-200, S-Cs and S-Co.
During the comparison, a new version of ISO 4037 was published, so some participants used the old version of the standard, and some participants used the new version. The change with the largest potential impact on the comparison result was the change of the recommended value of conversion coefficients for N-40 and S-Cs radiation qualities. However, this change was significantly smaller than the expanded uncertainty of the conversion coefficient. All the results were reported as received, without corrections for different versions of the ISO standard.
The transfer chamber stability was evaluated by performing repeated measurements in VINS, and the uncertainty due to the stability was added to the uncertainty of the Degrees of Equivalence.
The comparison was delayed by 7 months, due to the COVID-19 pandemic and the malfunction of the adapter cable.

16. Acknowledgement

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Annex A: Measurement uncertainty budgets, as reported by the participants

VINS

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	35.29
$K_{a,ref}$ (mGy/h):	5.21
$H^*(10)_{ref}$ (mSv/h):	6.15
N_H (µSv/nC) (comparison result):	26.34

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.52%	0.62%	6.5E-05	
Collected charge / ionization current	0.01%		1E-08	
Air density correction		0.10%	1E-06	
Source to chamber distance			0	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.33%	1.1E-05	Electrometer non-linearity (0.14 %) and beam quality (0.3 %)
Combined uncertainty, *H(10)**			0.00048	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%	0.01%	5E-08	
Air density correction		0.10%	1E-06	
Source to chamber distance		0.12%	1.4E-06	
Other sources of uncertainty		0.02%	4E-08	correction k_t
Combined uncertainty, *Q/I*			2.5E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.19%	

VINS

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	35.29
$K_{a,ref}$ (mGy/h):	3.57
$H^*(10)_{ref}$ (mSv/h):	6.11
N_H (µSv/nC) (comparison result):	29.66

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.52%	0.61%	6.4E-05	
Collected charge / ionization current	0.02%		4E-08	
Air density correction		0.10%	1E-06	
Source to chamber distance			0	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.33%	1.1E-05	Electrometer non-linearity (0.14 %) and beam quality (0.3 %)
Combined uncertainty, *H(10)**			0.00048	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.01%	0.01%	2E-08	
Air density correction		0.10%	1E-06	
Source to chamber distance		0.12%	1.4E-06	
Other sources of uncertainty		0.03%	9E-08	correction k_t
Combined uncertainty,*Q/I*			2.6E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.19%	

VINS

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	35.29
$K_{a,ref}$ (mGy/h):	4.12
$H^*(10)_{ref}$ (mSv/h):	6.02
N_H (µSv/nC) (comparison result):	29.95

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.52%	0.60%	6.3E-05	
Collected charge / ionization current	0.07%		4.9E-07	
Air density correction		0.10%	1E-06	
Source to chamber distance			0	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.33%	1.1E-05	Electrometer non-linearity (0.14 %) and beam quality (0.3 %)
Combined uncertainty, *H(10)**			0.00048	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.06%	0.01%	3.7E-07	
Air density correction		0.10%	1E-06	
Source to chamber distance		0.12%	1.4E-06	
Other sources of uncertainty		0.09%	8.1E-07	correction k_t
Combined uncertainty,*Q/I*			3.6E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.19%	

VINS

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	150
Field diameter (cm):	30.82
$K_{a,ref}$ (mGy/h):	0.526
$H^*(10)_{ref}$ (mSv/h):	0.631
N_H (µSv/nC) (comparison result):	29.46

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.52%	0.42%	4.5E-05	
Collected charge / ionization current	0.05%		2.5E-07	
Air density correction		0.10%	1E-06	
Source to chamber distance			0	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.14%	2E-06	Electrometer non-linearity
Combined uncertainty, *H(10)**			0.00045	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.07%	0.04%	6.5E-07	
Air density correction		0.10%	1E-06	
Source to chamber distance		0.16%	2.6E-06	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			4.2E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.13%	

VINS

Radiation quality:	S-Co
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	41.09
$K_{a,ref}$ (mGy/h):	1.75
$H^*(10)_{ref}$ (mSv/h):	2.03
N_H (µSv/nC) (comparison result):	28.26

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.52%	0.41%	4.4E-05	
Collected charge / ionization current	0.03%		9E-08	
Air density correction		0.10%	1E-06	
Source to chamber distance			0	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.14%	2E-06	Electrometer non-linearity
Combined uncertainty, *H(10)**			0.00045	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%	0.02%	8E-08	
Air density correction		0.10%	1E-06	
Source to chamber distance		0.12%	1.4E-06	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			2.5E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.12%	

PTB

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	250
Field diameter (cm):	43
$K_{a,ref}$ (mGy/h):	N/A
$H^*(10)_{ref}$ (mSv/h):	5.98
N_H (µSv/nC) (comparison result):	26.19

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		1.00%	0.0001	corrected for air density
Collected charge / ionization current		0.10%	1E-06	
Air density correction			0	
Source to chamber distance			0	included in calibration coefficient
Conversion coefficient		1.00%	0.0001	
Other sources of uncertainty		0.54%	2.9E-05	long term stability of monitor chamber and inhomogenity of radiation field
Combined uncertainty, *H(10)**			0.00023	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10%		1E-06	corrected for air density
Air density correction			0	
Source to chamber distance		0.09%	8.1E-07	
Other sources of uncertainty			0	
Combined uncertainty, *Q/I*			1.8E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		1.52%	

PTB

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	250
Field diameter (cm):	40
$K_{a,ref}$ (mGy/h):	N/A
$H^*(10)_{ref}$ (mSv/h):	5.99
N_H (µSv/nC) (comparison result):	29.31

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		1.00%	0.0001	corrected for air density
Collected charge / ionization current		0.10%	1E-06	
Air density correction			0	
Source to chamber distance			0	included in calibration coefficient
Conversion coefficient		1.00%	0.0001	
Other sources of uncertainty		0.54%	2.9E-05	long term stability of monitor chamber and inhomogenity of radiation field
Combined uncertainty, *H(10)**			0.00023	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.09%		8.1E-07	corrected for air density
Air density correction			0	
Source to chamber distance		0.09%	8.1E-07	
Other sources of uncertainty			0	
Combined uncertainty, *Q/I*			1.6E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		1.52%	

PTB

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	250
Field diameter (cm):	40
$K_{a,ref}$ (mGy/h):	N/A
$H^*(10)_{ref}$ (mSv/h):	5.97
N_H (µSv/nC) (comparison result):	29.34

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		1.00%	0.0001	corrected for air density
Collected charge / ionization current		0.10%	1E-06	
Air density correction		1.00%	0.0001	
Source to chamber distance			0	included in calibration coefficient
Conversion coefficient			0	
Other sources of uncertainty		0.54%	2.9E-05	long term stability of monitor chamber and inhomogenity of radiation field
Combined uncertainty, *H(10)**			0.00023	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10%		1E-06	corrected for air density
Air density correction			0	
Source to chamber distance		0.09%	8.1E-07	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			1.8E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)}$ =		1.52%	

PTB

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	278.2
Field diameter (cm):	58.8
$K_{a,ref}$ (mGy/h):	4.92
$H^*(10)_{ref}$ (mSv/h):	5.95
N_H (µSv/nC) (comparison result):	29.99

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.84%	7.1E-05	
Collected charge / ionization current			0	
Air density correction			0	
Source to chamber distance			0	
Conversion coefficient		1.00%	0.0001	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00017	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%		9E-08	
Air density correction		0.01%	1E-08	
Source to chamber distance		0.08%	6.4E-07	
Other sources of uncertainty		0.54%	2.9E-05	Reproducibility of source position and inhomogenity of radiation field
Combined uncertainty,*Q/I*			3E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		1.42%	

PTB

Radiation quality:	S-Co
Focus-detector-distance FDD (cm):	113.3
Field diameter (cm):	27.6
$K_{a,ref}$ (mGy/h):	N/A
$H^*(10)_{ref}$ (mSv/h):	5.95
N_H (µSv/nC) (comparison result):	28.62

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.84%	7.1E-05	
Collected charge / ionization current			0	
Air density correction			0	
Source to chamber distance			0	
Conversion coefficient		1.00%	0.0001	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00017	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%		9E-08	
Air density correction		0.01%	1E-08	
Source to chamber distance		0.20%	4E-06	
Other sources of uncertainty		0.54%	2.9E-05	Reproducibility of source position and inhomogenity of radiation field
Combined uncertainty,*Q/I*			3.3E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		1.43%	

HMI/IRB-SSDL

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	300
Field diameter (cm):	60
$K_{a,ref}$ (mGy/h):	4.39
$H^*(10)_{ref}$ (mSv/h):	5.27
N_H (µSv/nC) (comparison result):	29.04

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.42%	1.8E-05	
Collected charge / ionization current	0.02%		2.3E-08	
Air density correction	0.05%	0.33%	1.1E-05	
Source to chamber distance		0.10%	1E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty	0.20%	1.12%	0.00013	long term stability, change in source position, measurements resolution, barometer resolution and calibration factor
Combined uncertainty, *H(10)**			0.00056	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%		3.2E-08	
Air density correction	0.05%	0.33%	1.1E-05	
Source to chamber distance		0.10%	1E-06	
Other sources of uncertainty		1.12%	0.00013	change in source position, measurements resolution, barometer resolution and calibration factor
Combined uncertainty,*Q/I*			0.00014	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.64%	

HMI/IRB-SSDL

Radiation quality:	S-Co
Focus-detector-distance FDD (cm):	100
Field diameter (cm):	30
$K_{a,ref}$ (mGy/h):	7.99
$H^*(10)_{ref}$ (mSv/h):	9.27
N_H (µSv/nC) (comparison result):	28.53

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.42%	1.8E-05	
Collected charge / ionization current	0.02%		4E-08	
Air density correction	0.06%	0.33%	1.1E-05	
Source to chamber distance		0.10%	1E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty	0.20%	1.12%	0.00013	long term stability, change in source position, measurements resolution, barometer resolution and calibration factor
Combined uncertainty, *H(10)**			0.00056	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.01%		1E-08	
Air density correction	0.06%	0.33%	1.1E-05	
Source to chamber distance		0.10%	1E-06	
Other sources of uncertainty		1.12%	0.00013	change in source position, measurements resolution, barometer resolution and calibration factor
Combined uncertainty,*Q/I*			0.00014	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.64%	

MIRS/IJS/F-2,O-2

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	100
Field diameter (cm):	18
$K_{a,ref}$ (mGy/h):	5.6
$H^*(10)_{ref}$ (mSv/h):	6.6
N_H (µSv/nC) (comparison result):	26.01

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.60%	0.50%	6.1E-05	u_B ... long term stability
Collected charge / ionization current	0.20%		4E-06	
Air density correction		0.20%	3.8E-06	
Source to chamber distance		0.12%	1.3E-06	
Conversion coefficient	2.00%		0.0004	
Other sources of uncertainty		0.50%	2.5E-05	x-ray stability
Combined uncertainty, *H(10)**			0.0005	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10%		1E-06	
Air density correction		0.20%	3.8E-06	
Source to chamber distance		0.12%	1.3E-06	
Other sources of uncertainty		0.50%	2.5E-05	x-ray stability
Combined uncertainty,*Q/I*			3.1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.29%	

MIRS/IJS/F-2,O-2

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	100
Field diameter (cm):	18
$K_{a,ref}$ (mGy/h):	4.2
$H^*(10)_{ref}$ (mSv/h):	7.2
N_H (µSv/nC) (comparison result):	29.05

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.60%	0.50%	6.1E-05	u_B ... long term stability
Collected charge / ionization current	0.20%		4E-06	
Air density correction		0.20%	3.8E-06	
Source to chamber distance		0.12%	1.3E-06	
Conversion coefficient	2.00%		0.0004	
Other sources of uncertainty		0.50%	2.5E-05	x-ray stability
Combined uncertainty, *H(10)**			0.0005	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10%		1E-06	
Air density correction		0.20%	3.8E-06	
Source to chamber distance		0.12%	1.3E-06	
Other sources of uncertainty		0.50%	2.5E-05	x-ray stability
Combined uncertainty, *Q/I*			3.1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.29%	

MIRS/IJS/F-2,O-2

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	100
Field diameter (cm):	40 x 40
$K_{a,ref}$ (mGy/h):	6.1
$H^*(10)_{ref}$ (mSv/h):	7.4
N_H (µSv/nC) (comparison result):	29.53

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.60%	0.50%	6.1E-05	u_B ... long term stability
Collected charge / ionization current	0.10%		1E-06	
Air density correction		0.20%	3.8E-06	
Source to chamber distance		0.12%	1.3E-06	
Conversion coefficient	2.00%		0.0004	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00047	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10%		1E-06	
Air density correction		0.20%	3.8E-06	
Source to chamber distance		0.12%	1.3E-06	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			6.1E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.18%	

SMU

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	48.6
$K_{a,ref}$ (mGy/h):	5.39
$H^*(10)_{ref}$ (mSv/h):	6.44
N_H (µSv/nC) (comparison result):	29.24

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.00%	0.53%	2.8E-05	
Collected charge / ionization current	0.01%	0.10%	1E-06	
Air density correction	0.00%	0.15%	2.3E-06	
Source to chamber distance	0.00%	0.05%	2.5E-07	
Conversion coefficient	2.00%	0.00%	0.0004	
Other sources of uncertainty	0.00%	0.00%	0	
Combined uncertainty, *H(10)**			0.00043	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%	0.10%	1.1E-06	
Air density correction	0.00%	0.15%	2.3E-06	
Source to chamber distance	0.00%	0.05%	2.5E-07	
Other sources of uncertainty	0.00%	0.00%	0	
Combined uncertainty,*Q/I*			3.6E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.09%	

SMU

Radiation quality:	S-Co
Focus-detector-distance FDD (cm):	600
Field diameter (cm):	145.9
$K_{a,ref}$ (mGy/h):	324.79
$H^*(10)_{ref}$ (mSv/h):	376.75
N_H (µSv/nC) (comparison result):	28.24

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.00%	0.44%	1.9E-05	
Collected charge / ionization current	0.01%	0.10%	1E-06	
Air density correction	0.00%	0.15%	2.3E-06	
Source to chamber distance	0.00%	0.05%	2.5E-07	
Conversion coefficient	2.00%	0.00%	0.0004	
Other sources of uncertainty	0.00%	2.00%	0.0004	The value for the kerma rate is higher than recomended value.
Combined uncertainty, $H^*(10)$			0.00082	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.01%	0.10%	1E-06	
Air density correction	0.00%	0.15%	2.3E-06	
Source to chamber distance	0.00%	0.05%	2.5E-07	
Other sources of uncertainty	0.00%	0.00%	0	
Combined uncertainty, Q/I			3.5E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$	2.87%		

IRCL/GAEC-EIM

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	29.4
$K_{a,ref}$ (mGy/h):	5.38
$H^*(10)_{ref}$ (mSv/h):	6.428
N_H (µSv/nC) (comparison result):	26.38

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.40%	1.6E-05	
Collected charge / ionization current		0.12%	1.4E-06	
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.6E-07	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty	0.24%	0.58%	3.9E-05	uniformity of radiation beam (type B) and Chamber stability (type A) taken the worst uncertainty of all qualities
Combined uncertainty, *H(10)**			0.00047	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current		0.12%	1.4E-06	
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.6E-07	
Other sources of uncertainty		0.76%	5.8E-05	uniformity of radiation beam
Combined uncertainty,*Q/I*			7.1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.32%	

IRCL/GAEC-EIM

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	29.4
$K_{a,ref}$ (mGy/h):	N/A
$H^*(10)_{ref}$ (mSv/h):	6.927
N_H (µSv/nC) (comparison result):	29.37

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		2.00%	0.0004	
Collected charge / ionization current		0.12%	1.4E-06	Difference in temperature between two places (Type B)
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.6E-07	
Conversion coefficient			0	
Other sources of uncertainty	0.24%	0.58%	3.9E-05	uniformity of radiation beam (type B) and Chamber stability (type A) taken the worst uncertainty of all qualities
Combined uncertainty, *H(10)**			0.00045	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current		0.12%	1.4E-06	Difference in temperature between two places (Type B)
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.6E-07	
Other sources of uncertainty		0.76%	5.8E-05	uniformity of radiation beam
Combined uncertainty,*Q/I*			7.1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.29%	

IRCL/GAEC-EIM

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	29.4
$K_{a,ref}$ (mGy/h):	N/A
$H*(10)_{ref}$ (mSv/h):	6.64257
N_H (µSv/nC) (comparison result):	29.12

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		2.00%	0.0004	
Collected charge / ionization current		0.12%	1.4E-06	Difference in temperature between two places (Type B)
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.6E-07	
Conversion coefficient			0	
Other sources of uncertainty	0.24%	0.58%	3.9E-05	uniformity of radiation beam (type B) and Chamber stability (type A) taken the worst uncertainty of all qualities
Combined uncertainty, *H*(10)*			0.00045	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current		0.12%	1.4E-06	Difference in temperature between two places (Type B)
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.6E-07	
Other sources of uncertainty		0.76%	5.8E-05	uniformity of radiation beam
Combined uncertainty,*Q/I*			7.1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.29%	

IRCL/GAEC-EIM

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	240
Field diameter (cm):	66.7
$K_{a,ref}$ (mGy/h):	N/A
$H^*(10)_{ref}$ (mSv/h):	6.17
N_H (µSv/nC) (comparison result):	30.08

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		1.50%	0.00023	
Collected charge / ionization current		0.12%	1.4E-06	Difference in temperature between two places (Type B)
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.4E-07	
Conversion coefficient			0	
Other sources of uncertainty	0.24%	0.58%	3.9E-05	uniformity of radiation beam (type B) and Chamber stability (type A) taken the worst uncertainty of all qualities
Combined uncertainty, *H(10)**			0.00028	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current		0.12%	1.4E-06	Difference in temperature between two places (Type B)
Air density correction	0.33%	0.08%	1.2E-05	
Source to chamber distance		0.06%	3.4E-07	
Other sources of uncertainty		0.58%	3.4E-05	uniformity of radiation beam
Combined uncertainty,*Q/I*			4.7E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		1.80%	

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Radiation quality:	N-40
Focus-detector-distance FDD (cm):	250
Field size (cm):	90
$K_{a,ref}$ (mGy/h):	5.12
$H^*(10)_{ref}$ (mSv/h):	6.14
N_H (µSv/nC) (comparison result):	26.76

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.00	0.40	0.16	
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	2 mm uncertainty for X-ray system
Conversion coefficient	0.00	2.00	4.00	
Other sources of uncertainty	0.00	0.00	0.00	
Combined uncertainty, *H(10)**			4.22	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	2 mm uncertainty for X-ray system
Other sources of uncertainty	0.45	0.00	0.20	repeatability of calibration. Max stdev between the 2 runs that were done for this comparison.
Combined uncertainty,*Q/I*			0.26	
Combined uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.115	

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Radiation quality:	N-100
Focus-detector-distance FDD (cm):	250
Field size (cm):	90
$K_{a,ref}$ (mGy/h):	3.40
$H^*(10)_{ref}$ (mSv/h):	5.81
N_H (µSv/nC) (comparison result):	29.84

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.00	0.40	0.16	
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 ^{o}C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	2 mm uncertainty for X-ray system
Conversion coefficient	0.00	2.00	4.00	
Other sources of uncertainty	0.00	0.00	0.00	
Combined uncertainty, *H(10)**			4.22	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 ^{o}C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	2 mm uncertainty for X-ray system
Other sources of uncertainty	0.45	0.00	0.20	repeatability of calibration. Max stdev between the 2 runs that were done for this comparison.
Combined uncertainty,*Q/I*			0.26	
Combined uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.115	

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Radiation quality:	N-200
Focus-detector-distance FDD (cm):	250
Field size (cm):	90
$K_{a,ref}$ (mGy/h):	3.83
$H^*(10)_{ref}$ (mSv/h):	5.60
N_H (µSv/nC) (comparison result):	29.79

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.00	0.40	0.16	
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	2 mm uncertainty for X-ray system
Conversion coefficient	0.00	2.00	4.00	
Other sources of uncertainty	0.00	0.00	0.00	
Combined uncertainty, *H(10)**			4.22	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	2 mm uncertainty for X-ray system
Other sources of uncertainty	0.45	0.00	0.20	repeatability of calibration. Max stdev between the 2 runs that were done for this comparison.
Combined uncertainty, *Q/I*			0.26	
Combined uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.115	

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Radiation quality:	Cs-137
Focus-detector-distance FDD (cm):	123.9
Field size (cm):	45
$K_{a,ref}$ (mGy/h):	5.11
$H^*(10)_{ref}$ (mSv/h):	6.18
N_H (µSv/nC) (comparison result):	30.03

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.00	0.40	0.16	
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	1 mm uncertainty for Cs,Co systems
Conversion coefficient	0.00	2.00	4.00	
Other sources of uncertainty	0.00	0.00	0.00	
Combined uncertainty, *H(10)**			4.22	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.08	0.00	0.01	1 mm uncertainty for Cs,Co systems
Other sources of uncertainty	0.45	0.00	0.20	repeatability of calibration. Max stdev between the 2 runs that were done for this comparison.
Combined uncertainty,*Q/I*			0.26	
Combined uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.116	

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Radiation quality:	Co-60
Focus-detector-distance FDD (cm):	82.5
Field size (cm):	30
$K_{a,ref}$ (mGy/h):	5.21
$H^*(10)_{ref}$ (mSv/h):	6.05
N_H (µSv/nC) (comparison result):	28.36

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.00	0.40	0.16	
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.12	0.00	0.01	1 mm uncertainty for Cs,Co systems
Conversion coefficient	0.00	2.00	4.00	
Other sources of uncertainty	0.00	0.00	0.00	
Combined uncertainty, *H(10)**			4.22	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.10	0.00	0.01	
Air density correction	0.00	0.20	0.04	0.5 °C temperature and 1 hPa pressure
Source to chamber distance	0.12	0.00	0.01	1 mm uncertainty for Cs,Co systems
Other sources of uncertainty	0.45	0.00	0.20	repeatability of calibration. Max stdev between the 2 runs that were done for this comparison.
Combined uncertainty, *Q/I*			0.27	
Combined uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.119	

GUM

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	25
$K_{a,ref}$ (mGy/h):	4.91
$H^*(10)_{ref}$ (mSv/h):	5.88
N_H (µSv/nC) (comparison result):	26.30

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.20%		4E-06	Primary standard - no calibration coefficient
Collected charge / ionization current	0.16%	0.02%	2.6E-06	
Air density correction	0.01%	0.01%	2E-08	
Source to chamber distance		0.01%	1E-08	
Conversion coefficient		2.00%	0.0004	ISO 4037-3
Other sources of uncertainty	0.18%	0.35%	1.5E-05	Combined uncertainty of correction factors and u(W/e)
Combined uncertainty, *H(10)**			0.00042	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%	0.02%	1.3E-07	
Air density correction	0.01%	0.01%	2E-08	
Source to chamber distance		0.01%	1E-08	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			1.6E-07	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.05%	

GUM

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	25
$K_{a,ref}$ (mGy/h):	3.34
$H^*(10)_{ref}$ (mSv/h):	5.71
N_H (µSv/nC) (comparison result):	28.79

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.20%		4E-06	Primary standard - no calibration coefficient
Collected charge / ionization current	0.23%	0.02%	5.3E-06	
Air density correction	0.01%	0.01%	2E-08	
Source to chamber distance		0.01%	1E-08	
Conversion coefficient		2.00%	0.0004	ISO 4037-3
Other sources of uncertainty	0.30%	0.35%	2.1E-05	Combined uncertainty of correction factors and u(W/e)
Combined uncertainty, *H*(10)*			0.00043	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%	0.02%	1.3E-07	
Air density correction	0.01%	0.01%	2E-08	
Source to chamber distance		0.01%	1E-08	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			1.6E-07	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.08%	

GUM

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	25
$K_{a,ref}$ (mGy/h):	4
$H^*(10)_{ref}$ (mSv/h):	5.85
N_H (µSv/nC) (comparison result):	29.38

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.20%		4E-06	Primary standard - no calibration coefficient
Collected charge / ionization current	0.24%	0.02%	5.8E-06	
Air density correction	0.01%	0.01%	2E-08	
Source to chamber distance		0.01%	1E-08	
Conversion coefficient		2.00%	0.0004	ISO 4037-3
Other sources of uncertainty	0.13%	0.35%	1.4E-05	Combined uncertainty of correction factors and u(W/e)
Combined uncertainty, *H(10)**			0.00042	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%	0.02%	1.3E-07	
Air density correction	0.01%	0.01%	2E-08	
Source to chamber distance		0.01%	1E-08	
Other sources of uncertainty			0	
Combined uncertainty, *Q/I*			1.6E-07	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.06%	

GUM

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	150
Field diameter (cm):	39
$K_{a,ref}$ (mGy/h):	4.966
$H^*(10)_{ref}$ (mSv/h):	6.008
N_H (µSv/nC) (comparison result):	29.64

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.18%	0.60%	3.9E-05	
Collected charge / ionization current	0.04%	0.04%	3.2E-07	
Air density correction	0.04%	0.05%	4.1E-07	
Source to chamber distance		0.03%	9E-08	
Conversion coefficient		2.00%	0.0004	ISO 4037-3
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00044	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.04%	0.04%	3.2E-07	
Air density correction	0.02%	0.05%	2.9E-07	
Source to chamber distance		0.03%	9E-08	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			7E-07	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.10%	

GUM

Radiation quality:	S-Co
Focus-detector-distance FDD (cm):	139
Field diameter (cm):	36
$K_{a,ref}$ (mGy/h):	5.255
$H^*(10)_{ref}$ (mSv/h):	6.096
N_H (µSv/nC) (comparison result):	28.55

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.18%	0.54%	3.2E-05	
Collected charge / ionization current	0.03%	0.03%	1.8E-07	
Air density correction	0.02%	0.05%	2.9E-07	
Source to chamber distance		0.04%	1.6E-07	
Conversion coefficient		2.00%	0.0004	ISO 4037-3
Other sources of uncertainty			0	
Combined uncertainty, *H*(10)*			0.00043	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.04%	0.04%	3.2E-07	
Air density correction	0.03%	0.05%	3.4E-07	
Source to chamber distance		0.04%	1.6E-07	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			8.2E-07	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i (u_{i,A}^2 + u_{i,B}^2)} =$		2.08%	

IST-LPSR-LMRI

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	38
$K_{a,ref}$ (mGy/h):	1.105
$H^*(10)_{ref}$ (mSv/h):	1.305
N_H (µSv/nC) (comparison result):	26.25

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.39%	1.5E-05	
Collected charge / ionization current	0.01%		1E-08	
Air density correction		0.03%	9E-08	
Source to chamber distance		0.10%	1E-06	
Conversion coefficient		1.97%	0.00039	
Other sources of uncertainty		0.03%	9E-08	
Combined uncertainty, *H(10)**			0.0004	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.01%		1E-08	Leakage to charge ratio of 0.37% (probably due to connection problems)
Air density correction		0.03%	9E-08	
Source to chamber distance		0.10%	1E-06	
Other sources of uncertainty		0.03%	9E-08	field size
Combined uncertainty, *Q/I*			1.2E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i (u_{i,A}^2 + u_{i,B}^2)} =$		2.01%	

IST-LPSR-LMRI

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	38
$K_{a,ref}$ (mGy/h):	0.581
$H^*(10)_{ref}$ (mSv/h):	0.994
N_H (µSv/nC) (comparison result):	30.00

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.40%	2E-05	
Collected charge / ionization current	0.01%		1E-08	
Air density correction		0.03%	9E-08	
Source to chamber distance		0.10%	1E-06	
Conversion coefficient		1.98%	0.0004	
Other sources of uncertainty		0.03%	9E-08	Field size
Combined uncertainty, *H(10)**			0.0004	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.16%		3E-06	Leakage to charge ratio with values between 0.014% and 2.1%, with tendency to increase through each set of measurements (probably due to connection problems)
Air density correction		0.03%	9E-08	
Source to chamber distance		0.10%	1E-06	
Other sources of uncertainty		0.03%	9E-08	
Combined uncertainty,*Q/I*			4E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.03%	

IST-LPSR-LMRI

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	38
$K_{a,ref}$ (mGy/h):	0.887
$H^*(10)_{ref}$ (mSv/h):	1.29
N_H (µSv/nC) (comparison result):	29.74

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.40%	1.6E-05	
Collected charge / ionization current	0.01%		1E-08	
Air density correction		0.03%	9E-08	
Source to chamber distance		0.10%	1E-06	
Conversion coefficient		1.98%	0.00039	
Other sources of uncertainty		0.03%	9E-08	
Combined uncertainty, *H*(10)*			0.00041	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%		9E-08	Leakage to charge ratio with values between 0.07% and 0.16% (probably due to connection problems)
Air density correction		0.03%	9E-08	
Source to chamber distance		0.10%	1E-06	
Other sources of uncertainty		0.03%	9E-08	
Combined uncertainty,*Q/I*			1.3E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i (u_{i,A}^2 + u_{i,B}^2)} =$		2.03%	

IST-LPSR-LMRI

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	38
$K_{a,ref}$ (mGy/h):	0.665
$H^*(10)_{ref}$ (mSv/h):	0.798
N_H (µSv/nC) (comparison result):	29.64

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard		0.29%	8.4E-06	
Collected charge / ionization current	0.24%		5.8E-06	
Air density correction		0.03%	9E-08	
Source to chamber distance		0.10%	1E-06	
Conversion coefficient		1.97%	0.00039	
Other sources of uncertainty		0.52%	2.7E-05	
Combined uncertainty, *H(10)**			0.00043	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%		4E-08	Leakage to charge ratio was 0.05%
Air density correction		0.04%	1.6E-07	
Source to chamber distance		0.10%	1E-06	
Other sources of uncertainty		0.03%	9E-08	Field size
Combined uncertainty,*Q/I*			1.3E-06	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.08%	

IMBiH

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	32.45
$K_{a,ref}$ (mGy/h):	5.14
$H^*(10)_{ref}$ (mSv/h):	6.17
N_H (µSv/nC) (comparison result):	26.69

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.26%	0.71%	5.7E-05	Type A contribution refers to stability of reference chamber+electrometer system, Type B contribution refers to uncertainty due to calibration coefficient of reference standard
Collected charge / ionization current	0.01%		1E-08	
Air density correction		0.17%	2.9E-06	
Source to chamber distance		0.23%	5.3E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.45%	2E-05	nonlinearity of electrometer sensitivity (0,14%, type B)+radiation beam quality (0,4%, TypeB)+homogeneity and field size (0,14%, type B)
Combined uncertainty, *H(10)**			0.00049	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%		4E-08	
Air density correction		0.17%	2.9E-06	
Source to chamber distance		0.23%	5.3E-06	
Other sources of uncertainty		0.14%	2E-06	homogeneity and field size (0,14%, type B)
Combined uncertainty, *Q/I*			1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.23%	

IMBiH

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	32.45
$K_{a,ref}$ (mGy/h):	3.45
$H^*(10)_{ref}$ (mSv/h):	5.90
N_H (µSv/nC) (comparison result):	29.19

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.26%	0.71%	5.7E-05	Type A contribution refers to stability of reference chamber+electrometer system, Type B contribution refers to uncertainty due to calibration coefficient of reference standard
Collected charge / ionization current	0.02%		4E-08	
Air density correction		0.17%	2.9E-06	
Source to chamber distance		0.23%	5.3E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.30%	9.2E-06	nonlinearity of electrometer sensitivity (0,14%, type B)+radiation beam quality (0,23%, TypeB)+homogeneity and field size (0,14%, type B)
Combined uncertainty, *H(10)**			0.00047	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.05%		2.5E-07	
Air density correction		0.17%	2.9E-06	
Source to chamber distance		0.23%	5.3E-06	
Other sources of uncertainty		0.14%	2E-06	homogeneity and field size (0,14%, type B)
Combined uncertainty,*Q/I*			1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.20%	

IMBiH

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	32.45
$K_{a,ref}$ (mGy/h):	4.14
$H^*(10)_{ref}$ (mSv/h):	6.04
N_H (µSv/nC) (comparison result):	29.20

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.26%	0.72%	5.9E-05	Type A contribution refers to stability of reference chamber+electrometer system, Type B contribution refers to uncertainty due to calibration coefficient of reference standard
Collected charge / ionization current	0.02%		4E-08	
Air density correction		0.17%	2.9E-06	
Source to chamber distance		0.23%	5.3E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.25%	6.5E-06	nonlinearity of electrometer sensitivity (0,14%, type B)+radiation beam quality (0,16%, TypeB)+homogeneity and field size (0,14%, type B)
Combined uncertainty, *H(10)**			0.00047	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%		9E-08	
Air density correction		0.17%	2.9E-06	
Source to chamber distance		0.23%	5.3E-06	
Other sources of uncertainty		0.14%	2E-06	
Combined uncertainty,*Q/I*			1E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.20%	

IMBiH

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	300
Field diameter (cm):	57.77
$K_{a,ref}$ (mGy/h):	4.60
$H^*(10)_{ref}$ (mSv/h):	5.57
N_H (µSv/nC) (comparison result):	29.46

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.25%	0.40%	0.00002225	Type A contribution refers to stability of reference chamber+electrometer system, Type B contribution refers to uncertainty due to calibration coefficient of reference standard
Collected charge / ionization current	0.01%		0.00000001	
Air density correction		0.17%	0.00000289	
Source to chamber distance		0.23%	0.00000529	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.24%	5.85E-06	nonlinearity of electrometer sensitivity (0,14%, type B)+change in source position (0,17%, TypeB)+radiation beam quality (0,10%, type B)
Combined uncertainty, *H(10)**			0.00043629	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%		0.00000009	
Air density correction		0.17%	0.00000289	
Source to chamber distance		0.23%	0.00000529	
Other sources of uncertainty			0	
Combined uncertainty, *Q/I*			0.00000827	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.11%	

TENMAK-NÜKEN

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	20
$K_{a,ref}$ (mGy/h):	5.011
$H^*(10)_{ref}$ (mSv/h):	6.013
N_H (µSv/nC) (comparison result):	26.00

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	1.75%		0.0003063	
Collected charge / ionization current	0.03%	0.26%	6.838E-06	
Air density correction	0.15%	0.49%	2.625E-05	
Source to chamber distance		0.07%	4.489E-07	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.0007398	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.01%	0.26%	6.77E-06	
Air density correction	0.15%	0.49%	2.625E-05	
Source to chamber distance		0.07%	4.489E-07	
Other sources of uncertainty			0	
Combined uncertainty, *Q/I*			3.347E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.78%	

TENMAK-NÜKEN

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	20
$K_{a,ref}$ (mGy/h):	3.511
$H^*(10)_{ref}$ (mSv/h):	5.957
N_H (µSv/nC) (comparison result):	28.84

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.40%		1.6E-05	
Collected charge / ionization current	0.01%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00045	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Other sources of uncertainty			0	
Combined uncertainty, *Q/I*			3.4E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.20%	

TENMAK-NÜKEN

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	20
$K_{a,ref}$ (mGy/h):	4.089
$H^*(10)_{ref}$ (mSv/h):	5.947
N_H (µSv/nC) (comparison result):	29.52

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.40%		1.6E-05	
Collected charge / ionization current	0.01%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00045	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.03%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Other sources of uncertainty			0	
Combined uncertainty, *Q/I*			3.4E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.20%	

TENMAK-NÜKEN

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	235
Field diameter (cm):	60
$K_{a,ref}$ (mGy/h):	4.963
$H^*(10)_{ref}$ (mSv/h):	6.005
N_H (µSv/nC) (comparison result):	29.84

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.60%		3.6E-05	
Collected charge / ionization current	0.01%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00047	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.02%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			3.3E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.24%	

TENMAK-NÜKEN

Radiation quality:	S-Co
Focus-detector-distance FDD (cm):	330
Field diameter (cm):	80
$K_{a,ref}$ (mGy/h):	4.942
$H*(10)_{ref}$ (mSv/h):	5.733
N_H (µSv/nC) (comparison result):	28.69

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.40%		1.6E-05	
Collected charge / ionization current	0.01%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty			0	
Combined uncertainty, *H(10)**			0.00045	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.01%	0.26%	6.8E-06	
Air density correction	0.15%	0.49%	2.6E-05	
Source to chamber distance		0.07%	4.5E-07	
Other sources of uncertainty			0	
Combined uncertainty,*Q/I*			3.3E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.20%	

INM MD

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	28
$K_{a,ref}$ (mGy/h):	3.848
$H^*(10)_{ref}$ (mSv/h):	6.58
N_H (µSv/nC) (comparison result):	28.62

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.50%	0.70%	7.4E-05	Stability.
Collected charge / ionization current	0.31%	0.11%	1.1E-05	Repeatability; Resolution.
Air density correction		0.01%	1E-08	
Source to chamber distance		0.14%	2E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.71%	5E-05	Temperature variation (difference in the temperature inside the chamber and the thermometer's reading); Nonlinearity; Energy dependence.
Combined uncertainty, *H(10)**			0.00054	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.21%	0.08%	5E-06	Repeatability; Resolution.
Air density correction		0.01%	1E-08	
Source to chamber distance		0.14%	2E-06	
Other sources of uncertainty		0.72%	5.2E-05	Temperature variation (difference in the temperature inside the chamber and the thermometer's reading); Nonlinearity.
Combined uncertainty,*Q/I*			5.9E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.44%	

INM MD

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	28
$K_{a,ref}$ (mGy/h):	4.267
$H^*(10)_{ref}$ (mSv/h):	6.23
N_H (µSv/nC) (comparison result):	29.63

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.50%	0.70%	7.4E-05	Stability.
Collected charge / ionization current	0.29%	0.10%	9.4E-06	Repeatability; Resolution.
Air density correction		0.01%	1E-08	
Source to chamber distance		0.14%	2E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.68%	4.6E-05	Temperature variation (difference in the temperature inside the chamber and the thermometer's reading); Nonlinearity; Energy dependence.
Combined uncertainty, *H(10)**			0.00053	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.25%	0.08%	6.9E-06	Repeatability; Resolution.
Air density correction		0.01%	1E-08	
Source to chamber distance		0.14%	2E-06	
Other sources of uncertainty		0.74%	5.5E-05	Temperature variation (difference in the temperature inside the chamber and the thermometer's reading); Nonlinearity.
Combined uncertainty,*Q/I*			6.4E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.44%	

INM MD

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	100
Field diameter (cm):	30
$K_{a,ref}$ (mGy/h):	3.713
$H^*(10)_{ref}$ (mSv/h):	4.492
N_H (µSv/nC) (comparison result):	29.51

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Calibration coefficient of the national/reference standard	0.50%	0.40%	4.1E-05	Stability.
Collected charge / ionization current	0.27%	0.12%	8.6E-06	Repeatability; Resolution.
Air density correction		0.01%	1E-08	
Source to chamber distance		0.29%	8.4E-06	
Conversion coefficient		2.00%	0.0004	
Other sources of uncertainty		0.36%	1.3E-05	Temperature variation (difference in the temperature inside the chamber and the thermometer's reading); Nonlinearity; Energy dependence.
Combined uncertainty, *H(10)**			0.00047	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,A}^2 + u_{i,B}^2$	Comment
Collected charge / ionization current	0.33%	0.11%	1.2E-05	Repeatability; Resolution.
Air density correction		0.01%	1E-08	
Source to chamber distance		0.29%	8.4E-06	
Other sources of uncertainty		0.35%	1.2E-05	Temperature variation (difference in the temperature inside the chamber and the thermometer's reading); Nonlinearity.
Combined uncertainty, *Q/I*			3.3E-05	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		2.24%	

NSC-IM

Radiation quality:	N-40
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	34
$K_{a,ref}$ (mGy/h):	31.566
$H^*(10)_{ref}$ (mSv/h):	37.248
N_H (µSv/nC) (comparison result):	26.588

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Calibration coefficient of the national/reference standard	0.11%	1.50%	1.50%	
Collected charge	0.11%	0.22%	0.25%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.05%	0.05%	
Conversion coefficient	–	2.00%	2.00%	
Other sources of uncertainty	–	–	–	
Combined uncertainty, *H(10)**			**2.51%**	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Collected charge	0.23%	0.22%	0.32%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.14%	0.14%	
Other sources of uncertainty	–	–	–	
Combined uncertainty, *Q*			**0.35%**	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		**2.54%**	

NSC-IM

Radiation quality:	N-100
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	34
$K_{a,ref}$ (mGy/h):	5.712
$H^*(10)_{ref}$ (mSv/h):	9.768
N_H (µSv/nC) (comparison result):	30.199

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Calibration coefficient of the national/reference standard	0.22%	1.50%	1.52%	
Collected charge	0.22%	0.10%	0.24%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.05%	0.05%	
Conversion coefficient	–	2.00%	2.00%	
Other sources of uncertainty	–	–	–	
Combined uncertainty, *H(10)**			**2.52%**	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Collected charge	0.15%	0.10%	0.18%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.14%	0.14%	
Other sources of uncertainty	–	–	–	
Combined uncertainty,*Q*			**0.23%**	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		**2.53%**	

NSC-IM

Radiation quality:	N-200
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	34
$K_{a,ref}$ (mGy/h):	9.157
$H^*(10)_{ref}$ (mSv/h):	13.37
N_H (µSv/nC) (comparison result):	30.354

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Calibration coefficient of the national/reference standard	0.22%	1.50%	1.52%	
Collected charge	0.22%	0.07%	0.23%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.05%	0.05%	
Conversion coefficient	–	2.00%	2.00%	
Other sources of uncertainty	–	–	–	
Combined uncertainty, *H*(10)*			**2.52%**	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Collected charge	0.14%	0.07%	0.16%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.14%	0.14%	
Other sources of uncertainty	–	–	–	
Combined uncertainty,*Q*			**0.22%**	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		**2.53%**	

NSC-IM

Radiation quality:	S-Cs
Focus-detector-distance FDD (cm):	200
Field diameter (cm):	60
$K_{a,ref}$ (mGy/h):	12.864
$H^*(10)_{ref}$ (mSv/h):	15.437
N_H (µSv/nC) (comparison result):	29.594

Reference *H**(10) determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Calibration coefficient of the national/reference standard	0.01%	0.42%	0.42%	
Collected charge	0.01%	0.06%	0.06%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.05%	0.05%	
Conversion coefficient	–	2.00%	2.00%	
Other sources of uncertainty	–	–	–	
Combined uncertainty, *H(10)**			**2.05%**	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Collected charge	0.01%	0.06%	0.06%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.14%	0.14%	
Other sources of uncertainty	–	–	–	
Combined uncertainty,*Q*			**0.16%**	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		**2.05%**	

NSC-IM

Radiation quality:	S-Co
Focus-detector-distance FDD (cm):	80
Field diameter (cm):	24
$K_{a,ref}$ (mGy/h):	0.594
$H^*(10)_{ref}$ (mSv/h):	0.689
N_H (µSv/nC) (comparison result):	29.008

Reference $H^*(10)$ determination				
Uncertainties in this table are stated with k=1				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Calibration coefficient of the national/reference standard	0.06%	0.40%	0.40%	
Collected charge	0.06%	0.13%	0.14%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.13%	0.13%	
Conversion coefficient	–	2.00%	2.00%	
Other sources of uncertainty	–	–	–	
Combined uncertainty, *H*(10)*			**2.05%**	
Transfer chamber measurements				
Source of uncertainty	$u_{i,A}$	$u_{i,B}$	$u_{i,C}$	Comment
Collected charge	0.03%	0.13%	0.13%	
Air density correction	–	0.05%	0.05%	
Source to chamber distance	–	0.35%	0.35%	
Other sources of uncertainty	–	–	–	
Combined uncertainty, *Q*			**0.38%**	
Combined standard uncertainty, N_H	$u = \sqrt{\sum_i \left(u_{i,A}^2 + u_{i,B}^2\right)} =$		**2.08%**	

Annex B: Measurement conditions and setup, as reported by the participants

VINS

Calibration date/period:	07.02.2019 - 19.02.2019.
Radiation quality:	N-40

Method of determination of *H**(10):	Reference chamber was calibrated in terms of air kerma free-in-air. Reference air kerma was mutliplied by conversion coefficient to obtain the reference *H*(*10)
Conversion factor value and source (if applicable):	1.18 Sv/Gy, obtained from ISO 4037-3:1999 (new ISO 4037-3:2019 is not yet available in VINS)
Description of the equipment used for calibration:	Reference chamber PTW 32002, electrometer PTW Unidos, monitor chamber PTW 34014 with PTW Unidos electrometer, thermometer, barometer, hygrometer, meter tape, lasers for positioning, X-ray generator Hopewell designs X80 – 225 kV-E
Description of calibration setup:	Chamber was calibrated by substitution method with monitor, HV was set to 40 kV, total filtration was 4.00 mm Al + 0.21 mm Cu, 1st HVL was 0.088 mm Cu
Picture of the calibration setup:	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_t}$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), kt correction for X-ray short term stability, Q is charge collected in 1 minute
Calibration was performed by:	Miloš Živanović, Nikola Kržanović, Miloš Đaletić

VINS

Calibration date/period:	07.02.2019 - 19.02.2019.
Radiation quality:	N-100

Method of determination of *H**(10):	Reference chamber was calibrated in terms of air kerma free-in-air. Reference air kerma was mutliplied by conversion coefficient to obtain the reference H*(10)
Conversion factor value and source (if applicable):	1.71 Sv/Gy, obtained from ISO 4037-3:1999 (new ISO 4037-3:2019 is not yet available in VINS)
Description of the equipment used for calibration:	Reference chamber PTW 32002, electrometer PTW Unidos, monitor chamber PTW 34014 with PTW Unidos electrometer, thermometer, barometer, hygrometer, meter tape, lasers for positioning, X-ray generator Hopewell designs X80 – 225 kV-E
Description of calibration setup:	Chamber was calibrated by substitution method with monitor, HV was set to 100 kV, total filtration was 4.00 mm Al + 5.00 mm Cu, 1st HVL was 1.14 mm Cu
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_t}$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), kt correction for X-ray short term stability, Q is charge collected in 1 minute
Calibration was performed by:	Miloš Živanović, Nikola Kržanović, Miloš Đaletić

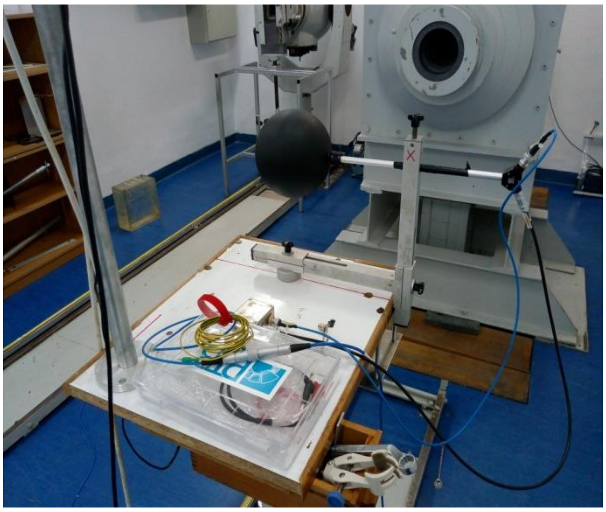
VINS

Calibration date/period:	07.02.2019 - 19.02.2019.
Radiation quality:	N-200

Method of determination of *H**(10):	Reference chamber was calibrated in terms of air kerma free-in-air. Reference air kerma was mutliplied by conversion coefficient to obtain the reference H*(10)
Conversion factor value and source (if applicable):	1.46 Sv/Gy, obtained from ISO 4037-3:1999 (new ISO 4037-3:2019 is not yet available in VINS)
Description of the equipment used for calibration:	Reference chamber PTW 32002, electrometer PTW Unidos, monitor chamber PTW 34014 with PTW Unidos electrometer, thermometer, barometer, hygrometer, meter tape, lasers for positioning, X-ray generator Hopewell designs X80 – 225 kV-E
Description of calibration setup:	Chamber was calibrated by substitution method with monitor, HV was set to 200 kV, total filtration was 4.00 mm Al + 2.00 mm Cu + 3.00 mm Sn + 1.00 mm Pb, 1st HVL was 4.16 mm Cu
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_t}$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), kt correction for X-ray short term stability, Q is charge collected in 1 minute
Calibration was performed by:	Miloš Živanović, Nikola Kržanović, Miloš Đaletić

VINS

Calibration date/period:	07.02.2019 - 19.02.2019.
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference chamber was calibrated in terms of air kerma free-in-air. Reference air kerma was mutliplied by conversion coefficient to obtain the reference H*(10)
Conversion factor value and source (if applicable):	1.20 Sv/Gy, obtained from ISO 4037-3:1999 (new ISO 4037-3:2019 is not yet available in VINS)
Description of the equipment used for calibration:	Reference chamber PTW 32002, electrometer PTW Unidos, thermometer, barometer, hygrometer, meter tape, lasers for positioning, multisource unit with Cs-137 source
Description of calibration setup:	Chamber was calibrated by substitution method. Attenuators were not used.
Picture of the calibration setup:	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user}}$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), Q is charge collected in 1 minute
Calibration was performed by:	Miloš Živanović, Nikola Kržanović, Miloš Đaletić

VINS

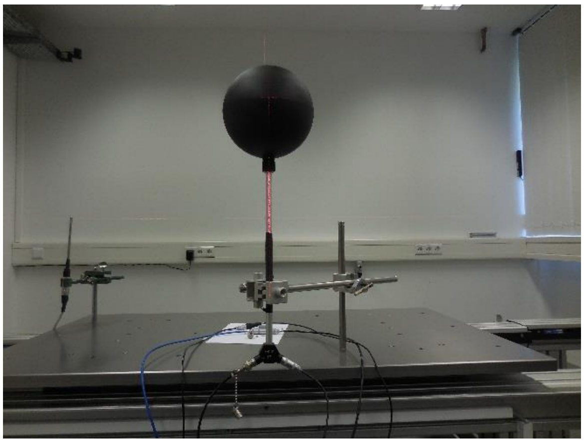
Calibration date/period:	07.02.2019 - 19.02.2019.
Radiation quality:	S-Co

Method of determination of *H**(10):	Reference chamber was calibrated in terms of air kerma free-in-air. Reference air kerma was mutliplied by conversion coefficient to obtain the reference H*(10)
Conversion factor value and source (if applicable):	1.16 Sv/Gy, obtained from ISO 4037-3:1999 (new ISO 4037-3:2019 is not yet available in VINS)
Description of the equipment used for calibration:	Reference chamber PTW 32002, electrometer PTW Unidos, thermometer, barometer, hygrometer, meter tape, lasers for positioning, multisource unit with Co-60 source
Description of calibration setup:	Chamber was calibrated by substitution method. Attenuators were not used.
Picture of the calibration setup: **see S-Cs**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user}}$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), Q is charge collected in 1 minute
Calibration was performed by:	Miloš Živanović, Nikola Kržanović, Miloš Đaletić

PTB

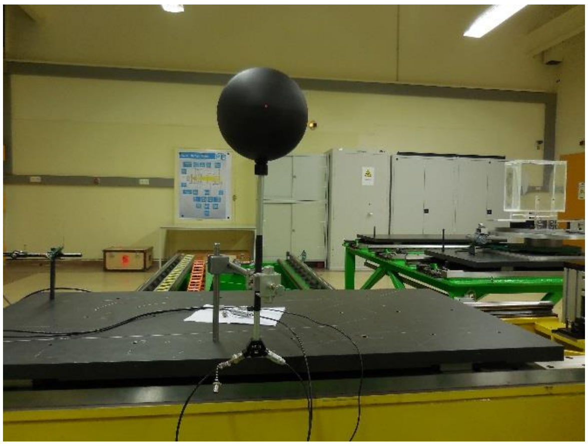
Calibration date/period:	08.04. to 16.04.2019
Radiation quality:	N-40

Method of determination of $H^*(10)$:	The procedure for determining the conventional quantity value of $H^*(10)$ was performed according to the international standard ISO 4037-3 [3] by using conversion coefficients $h^*_K(10;U)$ from air kerma free-in-air K_a to ambient dose equivalent, $H^*(10)$ for the radiation quality U: $\dot{H}^*(10)=h^*_K(10;U)^*\dot{K}_a$, The conventional quantity value of air kerma rate is traceable to the PTB primary standard laboratory for air kerma free-in-air. For the generated X-ray field, a high stable ionisation chamber (PTW, Type No. M23361, volume: 30 cm^3,) was calibrated against the K_a – primary standard chambers for X-radiation. By means of this chamber the conventional quantity value of the air kerma free-in-air, K_a, is transferred to the monitor chamber of the X-ray facility used. The monitor chamber coefficient N_{MK} (quotient between K_a and the chamber charge measured) is determined for each radiation quality and at each point of test. The quotient between K_a and the measured irradiation time is then the conventional quantity value of $\dot{K}_a$. At the X-ray facility, the conversion coefficient from K_a to $H^*(10)$ at the point of test was determined by means of X-ray spectrometry. A detailed description of the X-ray spectrometry including information about the spectrometer and the electronic devices used and a detailed description of the determination of the conversion coefficients are given in [Ankerhold, U., Catalogue of X-ray spectra and their characteristic data – ISO and DIN radiation qualities, therapy and diagnostic radiation qualities, unfiltered X-ray spectra –, PTB-Report, PTB-Dos-34, 119 p., April 2000, ISBN 3-89701-513-7]. There, a detailed analysis of the uncertainty is given, too.
Conversion factor value and source (if applicable):	1,197 The conversion coefficient is determined by spectrometry with a HPGe spectrometer and using an unfolding procedure.
Description of the equipment used for calibration:	The charge measurements were done with a PTB-developed electrometer [G. Buchholz, Ladungsmesser, PTB-Report, PTB-EW-12, July 2004, ISBN 3-86509-158-X] and have been repeated at least 6 times. The resulting current has been corrected for leakage current and for environmental conditions (temperature and pressure).
Description of calibration setup:	Calibration was done by using a tracable calibrated monitor transmission ionisation camber.

Picture of the calibration setup: 	
Determination of calibration coefficients (list all used corrections):	At the X-ray equipment, parallel to the current measurement of the transfer chamber the air kerma rate was determined by the monitor chamber. Multiplication with the conversion coefficient gives the conventional quantity value of the ambient dose equivalent rate, $\dot{H}^*(10)$: $\dot{H}^*(10) = h^*_K\,(10;U)\cdot\dot{K}_a$ with $\dot{K}a = N_{MK} \cdot I_{MK} \cdot k_\rho$ I_{MK} is the current measured by the monitor chamber, N_{MK} is the monitor chamber coefficient (see section 4.1). k_ρ is the correction factor for considering the environmental influences (temperature and pressure). As the results of the calibration measurements the calibration coefficient in Sv/C is given at each radiation quality by: $N_H=(\dot{H}^*(10))/I$
Calibration was performed by:	Simone Janßen

PTB

Calibration date/period:	08.04. to 16.04.2019
Radiation quality:	N-100

Method of determination of *H**(10):	see N-40
Conversion factor value and source (if applicable):	1,707 The conversion coefficient is determined by spectrometry with a HPGe spectrometer and using an unfolding procedure.
Description of the equipment used for calibration:	see N-40
Description of calibration setup:	see N-40
Picture of the calibration setup: 	
Determination of calibration coefficients (list all used corrections):	see N-40
Calibration was performed by:	Simone Janßen

PTB

Calibration date/period:	08.04. to 16.04.2019
Radiation quality:	N-200

Method of determination of *H**(10):	see N-40
Conversion factor value and source (if applicable):	1,46 The conversion coefficient is determined by spectrometry with a HPGe spectrometer and using an unfolding procedure.
Description of the equipment used for calibration:	see N-40
Description of calibration setup:	see N-40
Picture of the calibration setup:	**see N-100**
Determination of calibration coefficients (list all used corrections):	see N-40
Calibration was performed by:	Simone Janßen

PTB

Calibration date/period:	08.04. to 16.04.2019
Radiation quality:	S-Cs

Method of determination of *H**(10):	See N-40 + For the irradiations at the gamma radiation facility, the doserate of the sources were determined in advance by measurements with the primary standard chambers. In cases where the doserate were too low to measure with the primary standard chambers, a secondary standard chamber with larger volume was used. This secondary standard chamber has been calibrated against the primary standard at higher doserates. At the gamma radiation facility, the conversion coefficient from ISO 4037-3:2019 was used.
Conversion factor value and source (if applicable):	1,21 ISO 4037-3:2019 and own verification
Description of the equipment used for calibration:	The charge measurements were done with a traceable-calibrated electrometer and have been repeated at least 6 times. The resulting current has been corrected for leakage current and for environmental conditions (temperature and pressure).
Description of calibration setup:	Calibration was done by using a built-up plate according to ISO 4037-3:2019.

Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	At the gamma radiation facility conventional quantity value of the ambient dose equivalent rate, $\dot{H}^*(10)$ was determined by multiplication of the air kerma rate $\dot{K}_a$ and the conversion coefficient : $\dot{H}^*(10) = h^*_K(10;U)\cdot\dot{K}_a$ As the results of the calibration measurements the calibration coefficient in Sv/C is given at each radiation quality by: $N_H=(\dot{H}^*(10))/I$
Calibration was performed by:	Simone Janßen

PTB

Calibration date/period:	08.04. to 16.04.2019
Radiation quality:	S-Co

Method of determination of *H**(10):	See N-40 + For the irradiations at the gamma radiation facility, the doserate of the sources were determined in advance by measurements with the primary standard chambers. In cases where the doserate were too low to measure with the primary standard chambers, a secondary standard chamber with larger volume was used. This secondary standard chamber has been calibrated against the primary standard at higher doserates. At the gamma radiation facility, the conversion coefficient from ISO 4037-3:2019 was used.
Conversion factor value and source (if applicable):	1,16 ISO 4037-3:2019 and own verification
Description of the equipment used for calibration:	see S-Cs
Description of calibration setup:	see S-Cs
Picture of the calibration setup: **see S-Cs**	
Determination of calibration coefficients (list all used corrections):	see S-Cs
Calibration was performed by:	Simone Janßen

HMI/IRB-SSDL

Calibration date/period:	21.05.2019.-23.05.2019.
Radiation quality:	S-Cs

Method of determination of *H**(10):	Air kerma is measured and multiplied with conversion factor.
Conversion factor value and source (if applicable):	ISO 4037:1999, 1.20, u=2%
Description of the equipment used for calibration:	TW30002, #184 - LS01 ion chamber, T10002 # 20566 - electrometer, TNC cable, Hopewell Designs (G10-2-2600-20CS/5Co GA)/Cs-137 source - activity 740 GBq 2004-02-18)
Description of calibration setup:	The HS-01 and LS-01 are both placed in the center of the radiation beam and exposed to the conditions of field diameter, distance and air kerma rate as stated in the Cs-137 data sheet. The method used is substitution method.

Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	The calibration coefficients are determined from the expression: $\mathbf{N_{H^*(10)} = \dot{H}^*(10) / (Q_{mean} - Q_{leak}) * k_{TP}}$ • $\dot{H}^*(10)$: the ambient dose equivalent dose rate in μSv/min sections • Qmean : the mean value of the accumulated charge (nC) over 60 sec (10 successive measurements), in nC/min • Qleak : the mean value of the accumulated leakage charge (nC) over 60 sec (10 successive measurements), as being measured without the presence of radiation, in nC/min • k_{TP} : the air density correction (temperature and pressure)
Calibration was performed by:	Maja Vojnic Kortmis

HMI/IRB-SSDL

Calibration date/period:	21.-23.05.2019.
Radiation quality:	S-Co

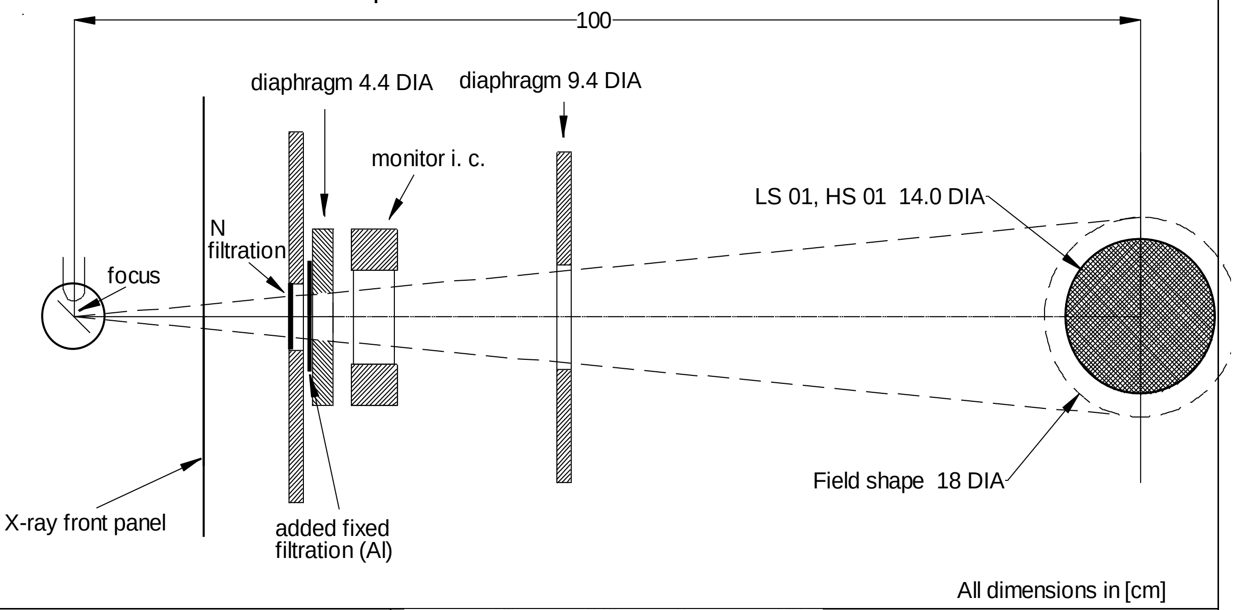
Method of determination of *H**(10):	Air kerma is measured and multiplied with conversion factor.
Conversion factor value and source (if applicable):	ISO 4037:1999, 1.16, u=2%
Description of the equipment used for calibration:	TW30002, #184 - LS01 ion chamber, T10002 # 20566 - electrometer, TNC cable, Hopewell Designs (G10-2-2600-20CS/5Co GA)/C0-60 source - activity 185 GBq 2004-02-18)
Description of calibration setup:	The HS-01 and LS-01 are both placed in the center of the radiation beam and exposed to the conditions of field diameter, distance and air kerma rate as stated in the Co-60 data sheet. The method used is substitution method.
Picture of the calibration setup: **see S-Cs**	
Determination of calibration coefficients (list all used corrections):	The calibration coefficients are determined from the expression: $\mathbf{N_{H^*(10)} = \dot{H}^*(10) / (Q_{mean} - Q_{leak}) * k_{TP}}$ • $\dot{H}^*(10)$: the ambient dose equivalent dose rate in μSv/min sections • Qmean : the mean value of the accumulated charge (nC) over 60 sec (10 successive measurements), in nC/min • Qleak : the mean value of the accumulated leakage charge (nC) over 60 sec (10 successive measurements), as being measured without the presence of radiation, in nC/min • k_{TP} : the air density correction (temperature and pressure)
Calibration was performed by:	Maja Vojnic Kortmis

MIRS/IJS/F-2,O-2

Calibration date/period:	22. - 27. 6. 2019
Radiation quality:	N-40

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	h_k = 1,18 (source: ISO 4037-3:1999(E))
Description of the equipment used for calibration:	Seibersdorf: LS 01 - reference ionization chamber and M50E transmisson monitor chamber, Keithey: 417 electrometer and 6514 electrometer.
Description of calibration setup:	Substitution method: LS 01 and HS 01 were exchanged at the reference point; the monitor chamber was used for control of X-ray stability. X-rays: x-ray tube COMET MXR-160/22, Fixed filt. = 3,6 mm Al, Added N filt. 0,2 mm Cu, 1.HVL = 0,085 mm Cu 2.HVL = 0,097 mm Cu

Picture of the calibration setup:



Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_t}$
Calibration was performed by:	Matjaž Mihelič

MIRS/IJS/F-2,O-2

Calibration date/period:	22. - 27. 6. 2019
Radiation quality:	N-100

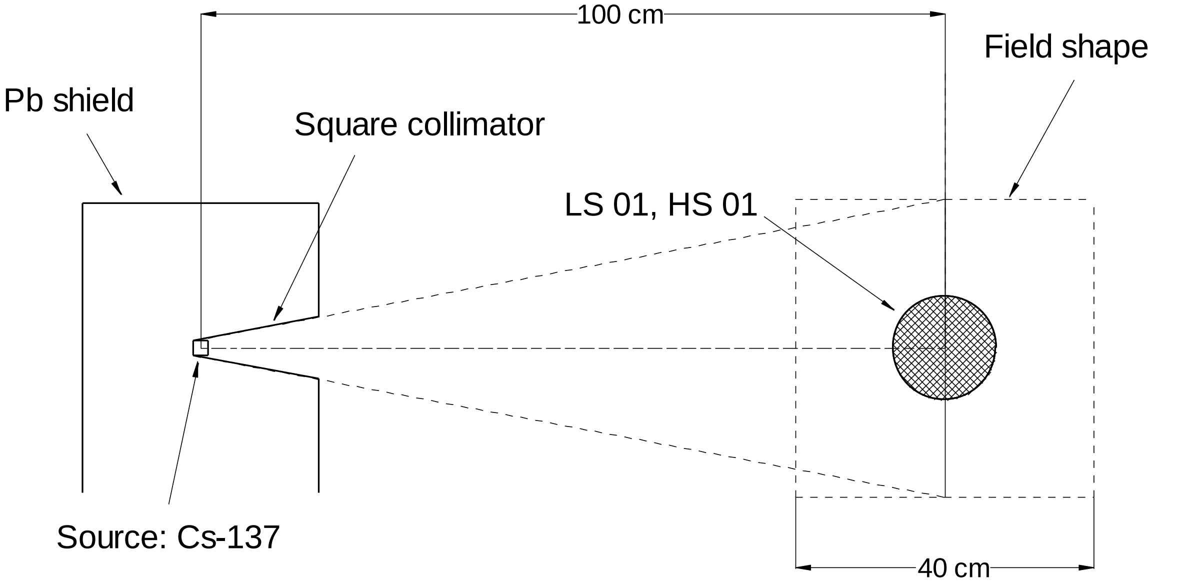
Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	h_k = 1,71 (source: ISO 4037-3:1999(E))
Description of the equipment used for calibration:	Seibersdorf: LS 01 - reference ionization chamber and M50E transmisson monitor chamber, Keithey: 417 electrometer and 6514 electrometer
Description of calibration setup:	Substitution method: LS 01 and HS 01 were exchanged at the reference point; the monitor chamber was used for control of X-ray stability. X-rays: x-ray tube COMET MXR-160/22, Fixed filt. = 3,6 mm Al, Added N filt. 5 mm Cu, 1.HVL = 1,09 mm Cu 2.HVL = 1,23 mm Cu
Picture of the calibration setup:	**see N-40**
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_t}$
Calibration was performed by:	Matjaž Mihelič

MIRS/IJS/F-2,O-2

Calibration date/period:	19. - 27. 6. 2019
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	h_k = 1,20 (source: ISO 4037-3:1999(E))
Description of the equipment used for calibration:	Seibersdorf: LS-01 - reference ionization chamber, Keithey: 417 electrometer
Description of calibration setup:	Substitution method: LS 01 and HS 01 were exchanged at the reference point.

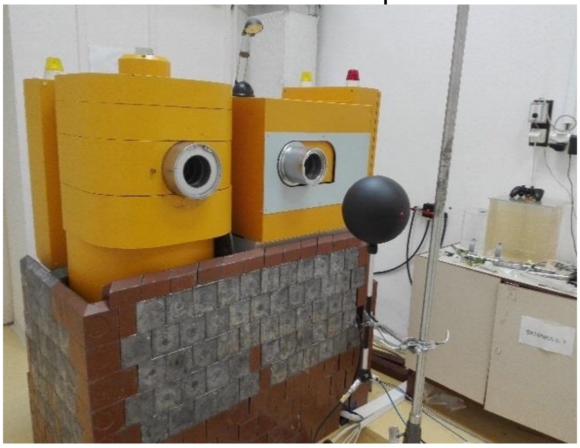
Picture of the calibration setup:



Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,\,user}}$
Calibration was performed by:	Matjaž Mihelič

SMU

Calibration date/period:	7/31/2019
Radiation quality:	S-Cs

Method of determination of *H**(10):	Determination of H*(10) was performed by ionization chamber ND1000 by measuring air kerma K and multiplied with conversion factor 1,2.
Conversion factor value and source (if applicable):	H*(10)=1,2*K (from ISO 4037)
Description of the equipment used for calibration:	measured with electromer Keithley 6517A; temperature and air pressure was measured on ALMEMO 2590 with sensor FHAD 46C2-L00
Description of calibration setup:	substitution method with chamber ND1000 (part of the standard equipment on SMU), calibration coefficient for this chamber is Nk = 22,57 µGy/C
Picture of the calibration setup: 	
Determination of calibration coefficients (list all used corrections):	where ref and user denote reference measurements and measurements with transfer chamber, ktp is correction for temperature and pressure, ks is correction for recombination loss, khalf is correction for half time of the ionising source, hk conversion coefficient from air kerma to H*(10) $$N_{\mathrm{H}} = \frac{Q_{ref} * N_{Ka} * k_{\mathrm{tp}} * k_{s} * k_{half} * h_{k}}{Q_{user} * k_{\mathrm{tp,user}} * k_{s,user} * k_{half,user}}$$
Calibration was performed by:	Stanislav Sandtner

SMU

Calibration date/period:	7/30/2019
Radiation quality:	S-Co

Method of determination of *H**(10):	Determination of H*(10) was performed by ionization chamber TW23361 by measuring air kerma K and multiplied with conversion factor 1,16.
Conversion factor value and source (if applicable):	H*(10)=1,16*K (from ISO 4037)
Description of the equipment used for calibration:	measured with electromer Keithley 6517A; temperature and air pressure was measured on ALMEMO 2590 with sensor FHAD 46C2-L00
Description of calibration setup:	substitution method with chamber TW23361 (part of the standard equipment on SMU), calibration coefficient for this chamber is Nk = 919,90 µGy/C
Picture of the calibration setup: 	
Determination of calibration coefficients (list all used corrections):	where ref and user denote reference measurements and measurements with transfer chamber, ktp is correction for temperature and pressure, ks is correction for recombination loss, khalf is correction for half time of the ionising source, hk conversion coefficient from air kerma to H*(10) $$N_{\mathrm{H}} = \frac{Q_{ref} * N_{Ka} * k_{\mathrm{tp}} * k_{s} * k_{half} * h_{k}}{Q_{user} * k_{\mathrm{tp,user}} * k_{s,user} * k_{half,user}}$$
Calibration was performed by:	Stanislav Sandtner

IRCL/GAEC-EIM

Calibration date/period:	19-25/11/2019
Radiation quality:	N-40

Method of determination of *H**(10):	Calculation through Kair calculation. In the calibration of 2019 in terms of N_H N-40 quality was not included. So the calibration factor Nk from 2015 was used for this quality Calibration Certificate Ref. Number: 6.25-50/15K
Conversion factor value and source (if applicable):	1,20 ISO4037:2019
Description of the equipment used for calibration:	LS01 Secondary standard ionization chamber and UNIDOS electrometer -Mercurial thermometer type: LABOTHERM Analog barometer type LUFT 2187.70692 SN:99127
Description of calibration setup:	The chamber was irradiated using the substitution method
Picture of the calibration setup: 	
Determination of calibration coefficients (list all used corrections):	NH user=H*(10) / Muser*kp $H^*(10) = K_a \cdot h_K^*(10;Q)$ $K_a = N_K * M * k_Q * k_\rho$ N_K calibration factor in terms of air kerma, reference conditions T=20°C, p=1013,25 hPa. k_Q correction factor for the radiation quality. k_ρ correction factor for the density of air, reference conditions T=20°C, p=1013,25 hPa.
Calibration was performed by:	ARGYRO BOZIARI

IRCL/GAEC-EIM

Calibration date/period:	19-25/11/2019
Radiation quality:	N-100

Method of determination of *H**(10):	H*(10)=N_{H^*} k(Q,a)(M-Mo)*k_p
Conversion factor value and source (if applicable):	Reference instrument LS01 SN:69 is calibrated in terms of H*(10) in PTB Calibration Certificate Ref. Numb:PTB-6.3-4094018 (6-7/3/2019)
Description of the equipment used for calibration:	LS01 Secondary standard ionization chamber and UNIDOS electrometer -Mercurial thermometer type: LABOTHERM Analog barometer type LUFT 2187.70692 SN:99127
Description of calibration setup:	The chamber was irradiated using the substitution method
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	NH user=H*(10) / Muser*kp $H^*(10) = N_H \cdot k(\mathrm{Q},\alpha) \cdot (\overline{M} - \overline{M}_0) \cdot k_\rho$ N_H: Calibration factor for the ambient dose equivalent at a depth of 10 mm, $H^*(10)$, for climatic reference conditions. $k(\mathrm{Q},\alpha)$: Correction factor for the radiation quality Q and the angle of incidence α. k_ρ: Correction factor for the air density ρ in the chamber volume, $k_\rho = \frac{T+273.15}{T_0+273.15} \cdot \frac{p_0}{p}$.
Calibration was performed by:	ARGYRO BOZIARI

IRCL/GAEC-EIM

Calibration date/period:	19-25/11/2019
Radiation quality:	N-200

Method of determination of *H**(10):	H*(10)=NH* k(Q,a)(M-Mo)*kp
Conversion factor value and source (if applicable):	Reference instrument LS01 SN:69 is calibrated in terms of H*(10) in PTB Calibration Certificate Ref. Numb:PTB-6.3-4094018 (6-7/3/2019)
Description of the equipment used for calibration:	LS01 Secondary standard ionization chamber and UNIDOS electrometer -Mercurial thermometer type: LABOTHERM Analog barometer type LUFT 2187.70692 SN:99127
Description of calibration setup:	The chamber was irradiated using the substitution method
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	NH user=H*(10) / Muser*kp $H^*(10) = N_H \cdot k(\mathrm{Q}, \alpha) \cdot (\overline{M} - \overline{M}_0) \cdot k_\rho$ N_H: Calibration factor for the ambient dose equivalent at a depth of 10 mm, $H^*(10)$, for climatic reference conditions. $k(\mathrm{Q}, \alpha)$: Correction factor for the radiation quality Q and the angle of incidence α. k_ρ: Correction factor for the air density ρ in the chamber volume, $k_\rho = \frac{T+273.15}{T_0+273.15} \cdot \frac{p_0}{p}$.
Calibration was performed by:	ARGYRO BOZIARI

IRCL/GAEC-EIM

Calibration date/period:	18-19/11/2019
Radiation quality:	S-Cs

Method of determination of *H**(10):	H*(10)=NH* k(Q,a)(M-Mo)*kp
Conversion factor value and source (if applicable):	Reference instrument LS01 SN:69 is calibrated in terms of H*(10) in PTB Calibration Certificate Ref. Numb:PTB-6.3-4094018 (6-7/3/2019)
Description of the equipment used for calibration:	LS01 Secondary standard ionization chamber and UNIDOS electrometer -Mercurial thermometer type: LABOTHERM Analog barometer type LUFT 2187.70692 SN:99127
Description of calibration setup:	
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	NH user=H*(10) / Muser*kp $H^*(10) = N_H \cdot k(\mathrm{Q},\alpha) \cdot (\overline{M} - \overline{M}_0) \cdot k_\rho$ N_H: Calibration factor for the ambient dose equivalent at a depth of 10 mm, $H^*(10)$, for climatic reference conditions. $k(\mathrm{Q},\alpha)$: Correction factor for the radiation quality Q and the angle of incidence α. k_ρ: Correction factor for the air density ρ in the chamber volume, $k_\rho = \frac{T+273.15}{T_0+273.15} \cdot \frac{p_0}{p}$.
Calibration was performed by:	ARGYRO BOZIARI

SCK • CEN/LNK

Calibration date:	2019-12-03 to 2019-12-05
Radiation quality:	N-40

Method of determination of *H**(10):	K_{air} measurements with a secondary standard PTW 1 liter ionization chamber in a matched beam and use of tabulated conversion coefficient.
Conversion factor value and source (if applicable):	1.20 (ISO 4037-3:2019 table 16&19)
Description of the equipment used for calibration:	PTW TW32002 SN 000521 1 liter ionization chamber connected to a Keithley 6517B SN 1335646 electrometer. A Radcal RC6M SN10251 6.0 cc was used to verify the Kair as well. The ionization chamber was last calibrated in 2016-11-09 at PTB (certificate 6.25-56/16K). The electrometer was last time calibrated in terms of charge (nC/nC) at the electricity laboratory of VSL, Delft NL, in 2016-07-21 (certificate 3352609.02).
Description of calibration setup:	The 100 kV Xstrahl X-ray tube was used. The installation was located in the KAL building, room 7, of LNK. The beam is horizontal and collimated with 20 degrees angle. Inherent filtration of the tube is 1 mm Be equivalent. The following additional filtration was used for N-40: 3.8 mm Al and 0.21 mm Cu. Ionization chambers were placed on an Al table, centered at 15 cm from the table surface. The substitution method was used for this comparison and the two chambers were measured in a short time interval one after the other (about 1 hour). A monitor chamber (IBA DAP chamber) was used to verify the beam stability for each beam quality. The beam quality is verified at LNK by HVL measurements and the maximum kV by photon spectroscopy with planar HPGe detector.
Picture of the calibration setup:	
Determination of calibration coefficients (list all used corrections):	1) air density inside the ionization chambers (pressure and temperature) 2) calibration coefficient of the electrometer k_{elec} (range and polarity dependent)
Calibration was performed by:	Liviu-Cristian Mihailescu

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Calibration date:	2019-12-03 to 2019-12-05
Radiation quality:	N-100

Method of determination of *H**(10):	K_{air} measurements with a secondary standard PTW 1 liter ionization chamber in a matched beam and use of tabulated conversion coefficient.
Conversion factor value and source (if applicable):	1.71 (ISO 4037-3:2019 table 16&19)
Description of the equipment used for calibration:	PTW TW32002 SN 000521 1 liter ionization chamber connected to a Keithley 6517B SN 1335646 electrometer. The ionization chamber was last calibrated in 2016-11-09 at PTB (certificate 6.25-56/16K). The electrometer was last time calibrated in terms of charge (nC/nC) at the electricity laboratory of VSL, Delft NL, in 2016-07-21 (certificate 3352609.02).
Description of calibration setup:	The 320 kV Xstrahl X-ray tube was used. The installation was located in the KAL building, room 7, of LNK. The beam is horizontal and collimated with 20 degrees angle. Inherent filtration of the tube is 4 mm Be equivalent. The following additional filtration was used for N-100: 3.8 mm Al and 5.0 mm Cu. Ionization chambers were placed on an Al table, centered at 15 cm from the table surface. The substitution method was used for this comparison and the two chambers were measured in a short time interval one after the other (about 1 hour). A monitor chamber (IBA DAP chamber) was used to verify the beam stability for each beam quality. The beam quality is verified at LNK by HVL measurements and the maximum kV by photon spectroscopy with planar HPGe detector.
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	1) air density inside the ionization chambers (pressure and temperature) 2) calibration coefficient of the electrometer k_{elec} (range and polarity dependent)
Calibration was performed by:	Liviu-Cristian Mihailescu

SCK • CEN/LNK

Calibration date:	2019-12-03 to 2019-12-05
Radiation quality:	N-200

Method of determination of *H**(10):	K^{air} measurements with a secondary standard PTW 1 liter ionization chamber in a matched beam and use of tabulated conversion coefficient.
Conversion factor value and source (if applicable):	1.46 (ISO 4037-3:2019 table 16&19)
Description of the equipment used for calibration:	PTW TW32002 SN 000521 1 liter ionization chamber connected to a Keithley 6517B SN 1335646 electrometer. The ionization chamber was last calibrated in 2016-11-09 at PTB (certificate 6.25-56/16K). The electrometer was last time calibrated in terms of charge (nC/nC) at the electricity laboratory of VSL, Delft NL, in 2016-07-21 (certificate 3352609.02).
Description of calibration setup:	The 320 kV Xstrahl X-ray tube was used. The installation was located in the KAL building, room 7, of LNK. The beam is horizontal and collimated with 20 degrees angle. Inherent filtration of the tube is 4 mm Be equivalent. The following additional filtration was used for N-200: 3.8 mm Al, 2.0 mm Cu, 3.0 mm Sn and 1.0 mm Pb. Ionization chambers were placed on an Al table, centered at 15 cm from the table surface. The substitution method was used for this comparison and the two chambers were measured in a short time interval one after the other (about 1 hour). A monitor chamber (IBA DAP chamber) was used to verify the beam stability for each beam quality. The beam quality is verified at LNK by HVL measurements and the maximum kV by photon spectroscopy with planar HPGe detector.
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	1) air density inside the ionization chambers (pressure and temperature) 2) calibration coefficient of the electrometer k_{elec} (range and polarity dependent)
Calibration was performed by:	Liviu-Cristian Mihailescu

SCK • CEN/LNK

Calibration date:	2019-12-03 to 2019-12-05
Radiation quality:	Cs-137

Method of determination of *H**(10):	K_{air} measurements with a secondary standard PTW 1 liter ionization chamber in a matched beam and use of tabulated conversion coefficient.
Conversion factor value and source (if applicable):	1.21 (ISO 4037-3:2019 table 16&19)
Description of the equipment used for calibration:	PTW TW32002 SN 000521 1 liter ionization chamber connected to a Keithley 6517B SN 1335646 electrometer. The ionization chamber was last calibrated in 2016-11-09 at PTB (certificate 6.25-56/16K). The electrometer was last time calibrated in terms of charge (nC/nC) at the electricity laboratory of VSL, Delft NL, in 2016-07-21 (certificate 3352609.02).
Description of calibration setup:	The horizontal Canberra type irradiator with Cs-137 source P12 was used. The installation was located in the KAL building, room 7, of LNK. The beam is horizontal and collimated with 20 degrees angle. Ionization chambers were placed on an Al table, centered at 15 cm from the table surface. The substitution method was used for this comparison and the two chambers were measured in a short time interval one after the other (about 1 hour).

Picture of the calibration setup:

The PMMA plate from the photo was not used in the measurements. Tests with PMMA plates were done as well.

Determination of calibration coefficients (list all used corrections):	1) air density inside the ionization chambers (pressure and temperature) 2) calibration coefficient of the electrometer k_{elec} (range and polarity dependent)
Calibration was performed by:	Liviu-Cristian Mihailescu

SCK • CEN/LNK

Calibration date:	2019-12-03 to 2019-12-05
Radiation quality:	Co-60

Method of determination of *H**(10):	K_{air} measurements with a secondary standard PTW 1 liter ionization chamber in a matched beam and use of tabulated conversion coefficient.
Conversion factor value and source (if applicable):	1.16 (ISO 4037-3:2019 table 16&19)
Description of the equipment used for calibration:	PTW TW32002 SN 000521 1 liter ionization chamber connected to a Keithley 6517B SN 1335646 electrometer. The ionization chamber was last calibrated in 2016-11-09 at PTB (certificate 6.25-56/16K). The electrometer was last time calibrated in terms of charge (nC/nC) at the eleectricty laboratory of VSL, Delft NL, in 2016-07-21 (certificate 3352609.02).
Description of calibration setup:	The panoramic Canberra type irradiator with Co-60 source was used. The installation was located in the KAL building, bunker room, of LNK. The beam is panoramic. Ionization chambers were placed on an Al table, centered at 15 cm from the table surface. The substitution method was used for this comparison and the two chambers were measured in a short time interval one after the other (about 1 hour).

Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	1) air density inside the ionization chambers (pressure and temperature) 2) calibration coefficient of the electrometer k_{elec} (range and polarity dependent)
Calibration was performed by:	Liviu-Cristian Mihailescu

GUM

Calibration date/period:	12/17/2019
Radiation quality:	N-40

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from new ISO 4037:2019 - 1,197 (linearly approximated for distance 2m)
Description of the equipment used for calibration:	Yxlon Y.TU-320-D03 tube with MG-325 X-ray system; Primary standard XT for medium X-rays manufactured at GUM; Electrometer Keithley 6514A (calibrated at GUM); Styroflex capacitors (calibrated at GUM)
Description of calibration setup:	Substitution method, without monitor chamber, filters used only for radiation quality determination (HV=39.2 kV, I=5.65 mA; filtration: 3.908 mmAl+0.201 mmCu; HVL= 0,084 mmCu)

Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_a * h_k}{Q_{user} * k_{d,user}} * \frac{t_{user}}{t_{ref}}$ $K_a = \frac{W}{e} * \frac{1}{1-g} * \frac{Q_{ref}}{m} * k_{d,ref} * \prod k_i$ where ref and user denote reference measurements and measurements with transfer chamber, k_d is correction for air density, h_k is conversion coefficient from air kerma to H*(10), ki are corrections for XT primary standard (k_a - air attenuation, k_{sc}- scattered radiation, k_{fl} – fluorescence, k_e - electron loss, k_s - ion recombination, k_{pol} - polarity, k_d - field distortion, k_p - wall transmission, k_l - aperture transmission, k_h - humidity)
Calibration was performed by:	Łukasz Michalik

GUM

Calibration date/period:	12/18/2019
Radiation quality:	N-100

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from new ISO 4037:2019 - 1,71
Description of the equipment used for calibration:	Yxlon Y.TU-320-D03 tube with MG-325 X-ray system; Primary standard XT for medium X-rays manufactured at GUM; Electrometer Keithley 6514A (calibrated at GUM); Styroflex capacitors (calibrated at GUM); digital barometer PTB330; thermometer PT-401; thermo-hygrometer PWT-401
Description of calibration setup:	Substitution method, without monitor chamber, filters used only for radiation quality determination (HV=98.2 kV; I=9.85 mA; filtration: 3.908 mmAl+5.008 mmCu; HVL=1.11 mmCu)
Picture of the calibration setup: same as N-40	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_a * h_k}{Q_{user} * k_{d,user}} * \frac{t_{user}}{t_{ref}}$ $K_a = \frac{W}{e} * \frac{1}{1-g} * \frac{Q_{ref}}{m} * k_{d,ref} * \prod k_i$ where ref and user denote reference measurements and measurements with transfer chamber, k_d is correction for air density, h_k is conversion coefficient from air kerma to H*(10), ki are corrections for XT primary standard (k_a - air attenuation, k_{sc}- scattered radiation, k_{fl} – fluorescence, k_e - electron loss, k_s - ion recombination, k_{pol} - polarity, k_d - field distortion, k_p - wall transmission, k_l - aperture transmission, k_h - humidity)
Calibration was performed by:	Łukasz Michalik

GUM

Calibration date/period:	12/19/2019
Radiation quality:	N-200

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from new ISO 4037:2019 - 1,46
Description of the equipment used for calibration:	Yxlon Y.TU-320-D03 tube with MG-325 X-ray system; Primary standard XT for medium X-rays manufactured at GUM; Electrometer Keithley 6514A (calibrated at GUM); Styroflex capacitors (calibrated at GUM)
Description of calibration setup:	Substitution method, without monitor chamber, filters used only for radiation quality determination (HV=198.0 kV; I=2.85 mA; filtration: 3.908 mmAl+2.005 mmCu +3.0 mmSn+1.0 mmPb; HVL=3.98 mmCu)
Picture of the calibration setup: same as N-40	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_a * h_k}{Q_{user} * k_{d,user}} * \frac{t_{user}}{t_{ref}}$ $K_a = \frac{W}{e} * \frac{1}{1-g} * \frac{Q_{ref}}{m} * k_{d,ref} * \prod k_i$ where ref and user denote reference measurements and measurements with transfer chamber, k_d is correction for air density, h_k is conversion coefficient from air kerma to H*(10), ki are corrections for XT primary standard (k_a - air attenuation, k_{sc}- scattered radiation, k_{fl} – fluorescence, k_e - electron loss, k_s - ion recombination, k_{pol} - polarity, k_d - field distortion, k_p - wall transmission, k_l - aperture transmission, k_h - humidity)
Calibration was performed by:	Łukasz Michalik

GUM

Calibration date/period:	20-23.12.2020
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from ISO 4037:2019 - 1,21
Description of the equipment used for calibration:	ionizing chamber LS-01 S/N 0085 (traceable to GUM primary standard); electrometer Keithley 6517A; styroflex capacitors; digital barometer PTB330; thermometer PT-401; thermo-hygrometer PWT-401 (all used equipment calibrated at GUM)
Description of calibration setup:	Substitution method
Picture of the calibration setup: 	
Determination of calibration coefficients (list all used corrections):	$N_{\mathrm{H}} = \frac{C_{ref} \cdot \mathrm{U}_{\mathrm{ref}} \cdot N_{Ka} \cdot k_{D,ref} \cdot h_K \cdot t_{comp}}{C_{comp} \cdot U_{comp} \cdot k_{\mathrm{D,comp}} \cdot t_{ref}}$ where ref and comp denote reference measurements and measurements with chamber HS-01, *C* is capacity of capacitor, *U* is measured voltage, *t* is time of measurement, N_{Ka} is calibration coefficient of reference chamber, k_D is correction for air density, h_k is conversion coefficient from air kerma to H*(10)
Calibration was performed by:	Michal Derlacinski

GUM

Calibration date/period:	23-30.12.2019
Radiation quality:	S-Co

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from ISO 4037:2019 - 1,16
Description of the equipment used for calibration:	ionizing chamber LS-01 S/N 0085 (traceable to GUM primary standard); electrometer Keithley 6517A; styroflex capacitors; digital barometer PTB330; thermometer PT-401; thermo-hygrometer PWT-401 (all used equipment calibrated at GUM)
Description of calibration setup:	Substitution method
Picture of the calibration setup: same as S-Cs	
Determination of calibration coefficients (list all used corrections):	$N_{\mathrm{H}} = \frac{C_{ref} \cdot \mathrm{U}_{\mathrm{ref}} \cdot N_{Ka} \cdot k_{D,ref} \cdot h_K \cdot t_{comp}}{C_{comp} \cdot U_{comp} \cdot k_{\mathrm{D,comp}} \cdot t_{ref}}$ where ref and comp denote reference measurements and measurements with chamber HS-01, C is capacity of capacitor, U is measured voltage, t is time of measurement, N_{Ka} is calibration coefficient of reference chamber, k_D is correction for air density, h_k is conversion coefficient from air kerma to H*(10)
Calibration was performed by:	Michal Derlacinski

IST-LPSR-LMRI

Calibration date/period:	19/2/2020 - 21/2/2020
Radiation quality:	N-40

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999 - 1,18
Description of the equipment used for calibration:	Chambers: PTW 32002 SN97 (reference)+ HS01 SN 112 (transfer); Electrometer: PTW UNIDOS 10002 SN 20033 Cables: PTW + cables that travel with the transfer chamber; PTH measurements: Vaisala PTU303 SN K4620012 X-Ray unit: Philips MCN 165 + generator YXLON MGC41
Description of calibration setup:	Method used for calibration: Substitution method Chamber position: geometric center of the chamber at the reference plane, aligned with the beam axis; Reference mark of the chamber facing the beam Electrometer HV polarity: (-) HV to chamber: 300 V Radiation quality: N40 @ 1 mA (ISO 4037-1:1996) Measured HVL: 0,079 mm Cu Total filtration according to ISO 4037-1:1996: Additional filtration of 0,21 mm Cu + inherent filtration, adjusted to 4 mm Al HV used: 40 kV

Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	$$K_{air,ref} = N_{Kair} \times Q_{ref} \times C_{PT,ref} \times k_{h,ref} \times k_{d,ref} \times k_{a,ref}$$ Where: $K_{air,ref}$ is the reference air kerma, Q_{ref} is the charge measured with the reference chamber, $C_{PT,ref}$ is the correction or temperature and preassure, $k_{h,ref}$ is the correction for humidity (=1), $k_{d,ref}$ is the correction for source to chamber (=1) and $k_{a,ref}$ is the correction for field size (=1) $$H^*(10)_{ref} = K_{air,ref} \times h_K$$ Where: $H^*(10)_{ref}$ is the reference ambient dose equivalent, h_K is the conversion coefficient from air kerma to H*(10) $$N_H = \frac{H^*(10)_{ref}}{Q_{user} \times C_{PT,user} \times k_{h,user} \times k_{d,user} \times k_{a,user}}$$ Where: , Q_{user} is the charge measured with the reference chamber, $C_{PT,user}$ is the correction or temperature and preassure, $k_{h,user}$ is the correction for humidity (=1), $k_{d,user}$ is the correction for source to chamber (=1) and $k_{a,user}$ is the correction for field size (=1)
Calibration was performed by:	Margarida Caldeira, Gonçalo Carvalhal, Luís Santos

IST-LPSR-LMRI

Calibration date/period:	20/2/2020 - 21/2/2020
Radiation quality:	N-100

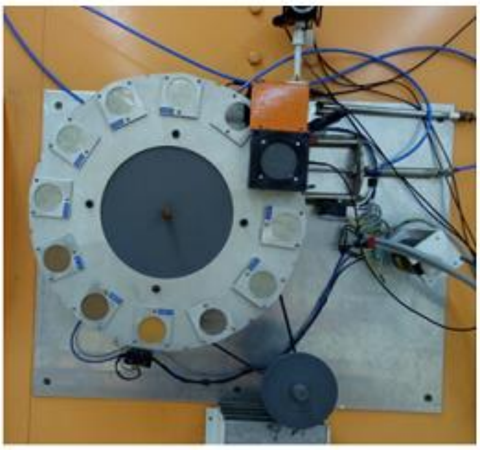
Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999 - 1,71
Description of the equipment used for calibration:	Chambers: PTW 32002 SN97 (reference)+ HS01 SN 112 (transfer) Electrometer: PTW UNIDOS 10002 SN 20033 Cables: PTW + cables that travel with the transfer chamber PTH measurements: Vaisala PTU303 SN K4620012 X-Ray unit: Philips MCN 165 + generator YXLON MGC41
Description of calibration setup:	Method used for calibration: Substitution method Chamber position: geometric center of the chamber at the reference plane, aligned with the beam axis; Reference mark of the chamber facing the beam Electrometer HV polarity: (-) HV to chamber: 300 V Radiation quality: N100 @ 1 mA (ISO 4037-1:1996) Measured HVL: 1,125 mm Cu Total filtration according to ISO 4037-1:1996: Additional filtration of 5 mm Cu + inherent filtration, adjusted to 4 mm Al HV used: 100 kV
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	**See N-40**
Calibration was performed by:	Margarida Caldeira, Gonçalo Carvalhal, Luís Santos

IST-LPSR-LMRI

Calibration date/period:	2/28/2020
Radiation quality:	N-200

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999 - 1,46
Description of the equipment used for calibration:	Chambers: PTW 32002 SN97 (reference)+ HS01 SN 112 (transfer); Electrometer: PTW UNIDOS 10002 SN 20033 Cables: PTW + cables that travel with the transfer chamber; PTH measurements: Vaisala PTU303 SN K4620012 X-Ray unit: Philips MCN 323 + generator YXLON MGC41
Description of calibration setup:	Method used for calibration: Substitution method Chamber position: geometric center of the chamber at the reference plane, aligned with the beam axis; Reference mark of the chamber facing the beam Electrometer HV polarity: (-) HV to chamber: 300 V Radiation quality: N200 @ 1 mA (ISO 4037-1: 1996) Measured HVL: 4,01 mm Cu Total filtration according to ISO 4037-1:1996: Additional filtration of 2 mm Cu, 3 mm Sn, 1 mmPb + inherent filtration, adjusted to 4 mm Al HV used: 200 kV

Picture of the calibration setup:



Determination of calibration coefficients (list all used corrections):	**See N-40**
Calibration was performed by:	Margarida Caldeira, Gonçalo Carvalhal, Luís Santos

IST-LPSR-LMRI

Calibration date/period:	06/2/2020 - 10/2/2020
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999 - 1,20
Description of the equipment used for calibration:	Chambers: PTW 32002 SN97 (reference)+ HS01 SN 112 (transfer); Electrometer: PTW UNIDOS 10002 SN 20033 Cables: PTW + cables that travel with the transfer chamber; PTH measurements: Vaisala PTU303 SN K4620012 Cs-137 irradiator: Shepherd (2.2 Ci)
Description of calibration setup:	Method used for calibration: Substitution method Chamber position: geometric center of the chamber at the reference plane, aligned with the beam axis; Reference mark of the chamber facing the beam Electrometer HV polarity: (-) HV to chamber: 300 V Radiation quality: Cs-137

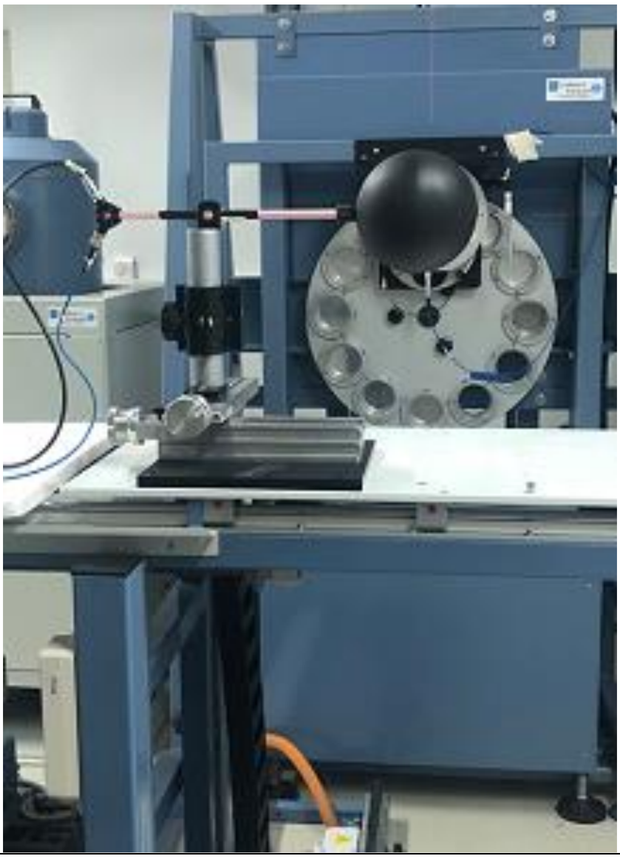
Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	**See N-40**
Calibration was performed by:	Margarida Caldeira, Gonçalo Carvalhal, Luís Santos

IMBiH

Calibration date/period:	17.09.2020 - 07.10.2020
Radiation quality:	N-40

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma (Ka) by method of substitution, and conversion coefficient from Ka to H*(10) is used.
Conversion factor value and source (if applicable):	Conversion coefficient from Air kerma to H*(10) = 1,20 (according to ISO 4037-3:2019)
Description of the equipment used for calibration:	The calibrations of the transfer chamber were performed against the IMBiH reference secondary-standard chamber, type PTW32002 S.N. 478, calibrated at the IAEA in 2019. The distance between the focus and reference point of the chamber was 200 cm and the field size diameter 32,45 cm. HVL determined at the laboratory is 2.701 mm Al. Ionization currents were measured using PTW UNIDOS Webline electrometer Type T10022 s.n. 298 based on charge measurement. Electrometer was calibrated in 2019 at the IAEA as a system of reference ionization and electrometer. No monitor chamber was used.
Description of calibration setup:	The IMBiH SSDL laboratory houses a high-stability generator and a bipolar tungsten-anode XRAY tube of type MXR-321, with a 3 mm beryllium window. Transfer chamber is oriented in such way that the Type and S/N are pointed towards the radiation source.
Picture of the calibration setup:	



Determination of calibration coefficients (list all used corrections):	Basic formula that was used with all corrections, and description of the corrections, for example: $$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_{elec}}$$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), kelec is electrometer calibration factor The Qcorr is corrected to the standard conditions of air temperature, pressure and relative humidity chosen for the comparison (T = 293.15 K, P = 101.325 kPa and h = 50 %)
Calibration was performed by:	Amra Šabeta and Milica Stupar

IMBiH

Calibration date/period:	17.09.2020 - 07.10.2020
Radiation quality:	N-100

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma (Ka) by method of substitution, and conversion coefficient from Ka to H*(10) is used.
Conversion factor value and source (if applicable):	Conversion coefficient from Air kerma to H*(10) = 1,71 (according to ISO 4037-3:2019)
Description of the equipment used for calibration:	The calibrations of the transfer chamber were performed against the IMBiH reference secondary-standard chamber, type PTW32002 S.N. 478, calibrated at the IAEA in 2019. The distance between the focus and reference point of the chamber was 200 cm and the field size diameter 32,45 cm. HVL determined at the laboratory is 1.075 mm Cu.Ionization currents were measured using PTW UNIDOS Webline electrometer Type T10022 s.n. 298 based on charge measurement. Electrometer was calibrated in 2019 at the IAEA as a system of reference ionization and electrometer. No monitor chamber was used.
Description of calibration setup:	The IMBiH SSDL laboratory houses a high-stability generator and a bipolar tungsten-anode xray tube of type MXR-321, with a 3 mm beryllium window. Transfer chamber is oriented in such way that the Type and S/N are pointed towards the radiation source.
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	Basic formula that was used with all corrections, and description of the corrections, for example: $$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_{elec}}$$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), kelec is electrometer calibration factor The Qcorr is corrected to the standard conditions of air temperature, pressure and relative humidity chosen for the comparison (T = 293.15 K, P = 101.325 kPa and h = 50 %)
Calibration was performed by:	Amra Šabeta and Milica Stupar

IMBiH

Calibration date/period:	17.09.2020 - 07.10.2020
Radiation quality:	N-200

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma (Ka) by method of substitution, and conversion coefficient from Ka to H*(10) is used.
Conversion factor value and source (if applicable):	Conversion coefficient from Air kerma to H*(10) = 1,46 (according to ISO 4037-3:2019)
Description of the equipment used for calibration:	The calibrations of the transfer chamber were performed against the IMBiH reference secondary-standard chamber, type PTW32002 S.N. 478, calibrated at the IAEA in 2019. The distance between the focus and reference point of the chamber was 200 cm and the field size diameter 32,45 cm. HVL determined at the laboratory is 3.981 mm Cu. Ionization currents were measured using PTW UNIDOS Webline electrometer Type T10022 s.n. 298 based on charge measurement. Electrometer was calibrated in 2019 at the IAEA as a system of reference ionization and electrometer. No monitor chamber was used.
Description of calibration setup:	The IMBiH SSDL laboratory houses a high-stability generator and a bipolar tungsten-anode xray tube of type MXR-321, with a 3 mm beryllium window. Transfer chamber is oriented in such way that the Type and S/N are pointed towards the radiation source.
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	Basic formula that was used with all corrections, and description of the corrections, for example: $$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_{elec}}$$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), kelec is electrometer calibration factor The Qcorr is corrected to the standard conditions of air temperature, pressure and relative humidity chosen for the comparison (T = 293.15 K, P = 101.325 kPa and h = 50 %)
Calibration was performed by:	Amra Šabeta and Milica Stupar

IMBiH

Calibration date/period:	17.09.2020 - 07.10.2020
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma (Ka) by method of substitution, and conversion coefficient from Ka to H*(10) is used.
Conversion factor value and source (if applicable):	Conversion coefficient from Air kerma to H*(10) = 1,21 (according to ISO 4037-3:2019)
Description of the equipment used for calibration:	The calibrations of the transfer chamber were performed against the IMBiH reference secondary-standard chamber, type PTW32002 S.N. 478, calibrated at the IAEA in 2019. The distance between the focus and reference point of the chamber was 300 cm and the field size diameter 57.77 cm. Ionization currents were measured using PTW UNIDOS Webline electrometer Type T10022 s.n. 298 based on charge measurement. Electrometer was calibrated in 2019 at the IAEA as a system consisting of reference ionization chamber and electrometer.
Description of calibration setup:	The IMBiH SSDL laboratory houses a Single source Cs-137 irradiator Mod. IM1-P2 by TEMA SINERGIE s.r.l. with source activity 740 GBq (01.Nov.2012). The diameter of the circular beam at 3 m distance from the focus was 57,77 cm. Transfer chamber is oriented in such way that the Type and S/N are pointed towards the radiation source.

Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	Basic formula that was used with all corrections, and description of the corrections, for example: $$N_H = \frac{Q_{ref} * N_{Ka} * k_{d,ref} * h_k}{Q_{user} * k_{d,user} * k_{elec}}$$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10), kelec is electrometer calibration factor The Qcorr is corrected to the standard conditions of air temperature, pressure and relative humidity chosen for the comparison (T = 293.15 K, P = 101.325 kPa and h = 50 %)
Calibration was performed by:	Amra Šabeta and Milica Stupar

TENMAK-NÜKEN

Calibration date/period:	08-19.02.2021
Radiation quality:	N-40

Method of determination of *H**(10):	Reference Air Kerma Rate Measurement multiplied by kerma air to ambient dose equivalent rate conversion coefficient and monitor chamber is used
Conversion factor value and source (if applicable):	1,20 ISO 4037-3 :2019
Description of the equipment used for calibration:	Reference Ionization chamber, PTW type TM23361 Unidos Webline electrometer, PTW Monitor chamber PTW TM786 Voltage divider, GE Built-in temperature/pressure mesurement probes.
Description of calibration setup:	Continuous irradiation X-ray system with a monitor chamber is used. Monitor chamber is placed in between beam apertures and calibrated against the reference standard. Total filtration is 4 mm Al and 0,2 mm Cu, measured HVL value is 2,707 mm Al. Tube potential is measured with voltage divider.

Picture of the calibration setup:

Determination of calibration coefficients (list all used corrections):	calibration of Monitor Chamber in terms of H*(10) $MF = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{m1} \times k_{d,m1}}$ where ref denotes reference and m1 denotes monitor chamber measurements calibration of transfer chamber, $N_H = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{user} \times k_{d,user}}$ where m2 denotes monitor chamber measurement and user denotes transfer chamber measurements.
Calibration was performed by:	Erinç REYHANİOĞLU

TENMAK-NÜKEN

Calibration date/period:	08-19.02.2021
Radiation quality:	N-100

Method of determination of *H**(10):	Reference Air Kerma Rate Measurement multiplied by kerma air to ambient dose equivalent rate conversion coefficient and monitor chamber is used
Conversion factor value and source (if applicable):	1,71 ISO 4037-3 : 2019
Description of the equipment used for calibration:	Reference Ionization chamber, PTW type TM32002 Unidos Webline electrometer, PTW Monitor chamber PTW TM786 Voltage divider, GE Built-in temperature/pressure mesurement probes.
Description of calibration setup:	Continuous irradiation X-ray system with a monitor chamber is used. Monitor chamber is placed in between beam apertures and calibrated against the reference standard. Total filtration is 4 mm Al and 4,99 mm Cu, measured HVL value is 1,09 mm Cu. Tube potential is measured with voltage divider.
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	calibration of Monitor Chamber in terms of H*(10) $MF = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{m1} \times k_{d,m1}}$ where ref denotes reference and m1 denotes monitor chamber measurements calibration of transfer chamber, $N_H = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{user} \times k_{d,user}}$ where m2 denotes monitor chamber measurement and user denotes transfer chamber measurements.
Calibration was performed by:	Erinç REYHANİOĞLU

TENMAK-NÜKEN

Calibration date/period:	08-19.02.2021
Radiation quality:	N-200

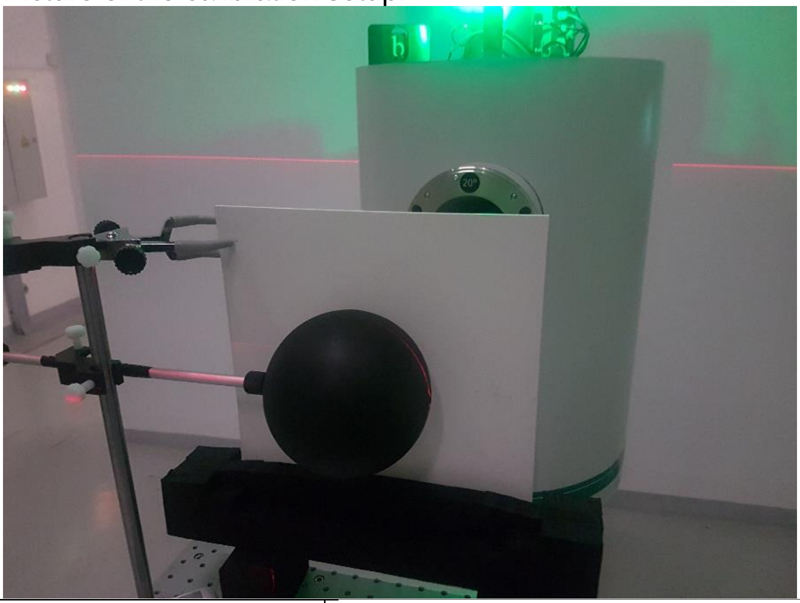
Method of determination of *H**(10):	Reference Air Kerma Rate Measurement multiplied by kerma air to ambient dose equivalent rate conversion coefficient and monitor chamber is used
Conversion factor value and source (if applicable):	1,46 ISO 4037-3 : 2019
Description of the equipment used for calibration:	Reference Ionization chamber, PTW type TM32002 Unidos Webline electrometer, PTW Monitor chamber PTW TM786 Voltage divider, GE Built-in temperature/pressure mesurement probes.
Description of calibration setup:	Continuous irradiation X-ray system with a monitor chamber is used. Monitor chamber is placed in between beam apertures and calibrated against the reference standard. Total filtration is 4 mm Al, 1,03 mm Pb, 3,04 mm Sn and 1,99 mm Cu, measured HVL value is 4,119 mm Cu. Tube potential is measured with voltage divider.
Picture of the calibration setup: **see N-40**	
Determination of calibration coefficients (list all used corrections):	calibration of Monitor Chamber in terms of H*(10) $MF = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{m1} \times k_{d,m1}}$ where ref denotes reference and m1 denotes monitor chamber measurements calibration of transfer chamber, $N_H = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{user} \times k_{d,user}}$ where m2 denotes monitor chamber measurement and user denotes transfer chamber measurements.
Calibration was performed by:	Erinç REYHANİOĞLU

TENMAK-NÜKEN

Calibration date/period:	10-19.03.2021
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference Air Kerma Rate Measurement multiplied by kerma air to ambient dose equivalent rate conversion coefficient and monitor chamber is used
Conversion factor value and source (if applicable):	1,21 ISO 4037-3 :2019
Description of the equipment used for calibration:	VF OG-8 Irradiator with collimator of 20 degree beam angle, housing the Cs, Co gamma sources. PTW TM32002 type ionization chamber as the reference standard. Built-in temperatur/pressure probes.
Description of calibration setup:	Collimated gamma radiation field. Substitution method is used. Measurement of transfer chamber is carried out with 3 mm PMMA plate in front of the chamber.

Picture of the calibration setup:



Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{user} \times k_{d,user}}$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10)
Calibration was performed by:	Erinç REYHANİOĞLU

TENMAK-NÜKEN

Calibration date/period:	10-19.03.2021
Radiation quality:	S-Co

Method of determination of *H**(10):	Reference Air Kerma Rate Measurement multiplied by kerma air to ambient dose equivalent rate conversion coefficient and monitor chamber is used
Conversion factor value and source (if applicable):	1,16 ISO 4037-3 :2019
Description of the equipment used for calibration:	VF OG-8 Irradiator with collimator of 20 degree beam angle, housing the Cs, Co gamma sources. PTW TM32002 type ionization chamber as the reference standard. Built-in temperatur/pressure probes.
Description of calibration setup:	Collimated gamma radiation field. Substitution method is used. Measurement of transfer chamber is carried out with 3 mm PMMA plate in front of the chamber.
Picture of the calibration setup: : **see S-Cs**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{Q_{ref} \times N_{Ka} \times k_{d,ref} \times h_k}{Q_{user} \times k_{d,user}}$ where ref and user denote reference measurements and measurements with transfer chamber, kd is correction for air density, hk conversion coefficient from air kerma to H*(10)
Calibration was performed by:	Erinç REYHANİOĞLU

INM MD

Calibration date/period:	5/4/2021
Radiation quality:	N-100

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used in acordance with SM ISO 4037-3:2020.
Conversion factor value and source (if applicable):	1,71 (SM ISO 4037-3:2020)
Description of the equipment used for calibration:	Ionizing chamber type: PTW 32002. No 000504; Electrometer type UNIDOS Webline, No 000334; Monitor Chamber type TW34014, No 000097; Electrometer type UNIDOS Webline, No 000335; X-Ray System, type X80-225 E, Hopewell Design's.
Description of calibration setup:	Voltage - 100 kV; Current - 10,0 mA; Distance - 200 cm. HVL - 1,13 mm Cu. The filters were used in acordance with SM ISO 4037-1:2020.
Picture of the calibration setup:	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{h \cdot N_k^{ref} \cdot M_m^{ref} \cdot m^{user} \cdot k_{TP0} \cdot k_{dist} \cdot k_Q \cdot k_{lin} \cdot k_r \cdot k_{st} \cdot k_{\Delta T}}{M_m^{user} \cdot m^{ref} \cdot k_{2TP0} \cdot k_{2lin} \cdot k_{2r} \cdot k_{2\Delta T} \cdot k_{2dist}}$ k_{TP0} – Air density correction k_{dist} – Calibration distance (chamber positioning) k_Q – Difference in the average beam energy in the primary and calibration labs k_r – Resolution k_{st} – Long term stability $k_{\Delta T}$ – Difference in the temperature inside the chamber and the thermometer's reading k_{lin} – Nonlinearity and nonconformity between the scales of electrometer M – Ionizing chamber reading m – Monitor chamber reading
Calibration was performed by:	Efimia LUCHIAN

INM MD

Calibration date/period:	5/4/2021
Radiation quality:	N-200

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used in acordance with SM ISO 4037-3:2020.
Conversion factor value and source (if applicable):	1,46 (SM ISO 4037-3:2020)
Description of the equipment used for calibration:	Ionizing chamber type: PTW 32002. No 000504; Electrometer type UNIDOS Webline, No 000334; Monitor Chamber type TW34014, No 000097; Electrometer type UNIDOS Webline, No 000335; X-Ray System, type X80-225 E, Hopewell Design's.
Description of calibration setup:	Voltage - 200 kV; Current - 2,6 mA; Distance - 200 cm. HVL - 4,04 mm Cu. The filters were used in acordance with SM ISO 4037-1:2020.
Picture of the calibration setup: **see N-100**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{h \cdot N_k^{ref} \cdot M_m^{ref} \cdot m^{user} \cdot k_{TP0} \cdot k_{dist} \cdot k_Q \cdot k_{lin} \cdot k_r \cdot k_{st} \cdot k_{\Delta T}}{M_m^{user} \cdot m^{ref} \cdot k_{2TP0} \cdot k_{2lin} \cdot k_{2r} \cdot k_{2\Delta T} \cdot k_{2dist}}$ k_{TP0} – Air density correction k_{dist} – Calibration distance (chamber positioning) k_Q – Difference in the average beam energy in the primary and calibration labs k_r – Resolution k_{st} – Long term stability $k_{\Delta T}$ – Difference in the temperature inside the chamber and the thermometer's reading k_{lin} – Nonlinearity and nonconformity between the scales of electrometer M – Ionizing chamber reading m – Monitor chamber reading
Calibration was performed by:	Efimia LUCHIAN

INM MD

Calibration date/period:	4/23/2021
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used in acordance with SM ISO 4037-3:2020.
Conversion factor value and source (if applicable):	1,21 (SM ISO 4037-3:2020)
Description of the equipment used for calibration:	Ionizing chamber type: PTW 32002. No 000504; Electrometer type UNIDOS Webline, No 000334
Description of calibration setup:	Distance - 100 cm. Attenuator - A10 (lead attenuator)
Picture of the calibration setup:	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{h \cdot N_k^{ref} \cdot M_m^{ref} \cdot m^{user} \cdot k_{TP0} \cdot k_{dist} \cdot k_Q \cdot k_{lin} \cdot k_r \cdot k_{st} \cdot k_{\Delta T}}{M_m^{user} \cdot m^{ref} \cdot k_{2TP0} \cdot k_{2lin} \cdot k_{2r} \cdot k_{2\Delta T} \cdot k_{2dist}}$ k_{TP0} – Air density correction k_{dist} – Calibration distance (chamber positioning) k_Q – Difference in the average beam energy in the primary and calibration labs k_r – Resolution k_{st} – Long term stability $k_{\Delta T}$ – Difference in the temperature inside the chamber and the thermometer's reading k_{lin} – Nonlinearity and nonconformity between the scales of electrometer M – Ionizing chamber reading m – Monitor chamber reading
Calibration was performed by:	Efimia LUCHIAN

NSC-IM

Calibration date/period:	26.05.; 22.06.; 23.06.; 24.06.; 25.06; 29.06.2021
Radiation quality:	N-40

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999.
Description of the equipment used for calibration:	National standard of Ukraine. Equipment for X-Ray radiation - X80-225-E X-Ray Irradiator from Hopewell Designs, Inc. (USA). HVL measurement. HVL1 = 0,088Cu. Electrometer - UNIDOS Webline, REF T10021, S/N 000999.
Description of calibration setup:	Direct measurement method. Air kerma - reference value. Charge - for the ionization chamber HS-01. Measurement of temperature and pressure.
Picture of the calibration setup (X80-225-E): 	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_{air,ref} \cdot h_K^*(10)}{Q_{user} \cdot k_{Tp}}; \quad R_{ref} = R_{user}$.
Calibration was performed by:	Andrei Orobinskyi, PhD, Chief of laboratory.

NSC-IM

Calibration date/period:	26.05.; 22.06.; 23.06.; 24.06.; 25.06; 29.06.2021
Radiation quality:	N-100

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999.
Description of the equipment used for calibration:	National standard of Ukraine. Equipment for X-Ray radiation - X80-225-E X-Ray Irradiator from Hopewell Designs, Inc. (USA). HVL measurement. HVL1 = 1,12Cu. Electrometer - UNIDOS Webline, REF T10021, S/N 000999.
Description of calibration setup:	Direct measurement method. Air kerma - reference value. Charge - for the ionization chamber HS-01. Measurement of temperature and pressure.
Picture of the calibration setup (X80-225-E): **see N-40**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_{air,ref} \cdot h_K^*(10)}{Q_{user} \cdot k_{Tp}}; \quad R_{ref} = R_{user}$.
Calibration was performed by:	Andrei Orobinskyi, PhD, Chief of laboratory.

NSC-IM

Calibration date/period:	26.05.; 22.06.; 23.06.; 24.06.; 25.06; 29.06.2021
Radiation quality:	N-200

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999.
Description of the equipment used for calibration:	National standard of Ukraine. Equipment for X-Ray radiation - X80-225-E X-Ray Irradiator from Hopewell Designs, Inc. (USA). HVL measurement. HVL1 = 4,12Cu. Electrometer - UNIDOS Webline, REF T10021, S/N 000999.
Description of calibration setup:	Direct measurement method. Air kerma - reference value. Charge - for the ionization chamber HS-01. Measurement of temperature and pressure.
Picture of the calibration setup (X80-225-E): **see N-40**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_{air,ref} \cdot h_K^*(10)}{Q_{user} \cdot k_{Tp}}; \quad R_{ref} = R_{user}$.
Calibration was performed by:	Andrei Orobinskyi, PhD, Chief of laboratory.

NSC-IM

Calibration date/period:	01.06.; 07.06.; 08.06.; 15.06.; 30.06; 01.07.2021
Radiation quality:	S-Cs

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999.
Description of the equipment used for calibration:	National standard of Ukraine. Equipment for gamma radiation UGV-1 (collimator: length - 150 mm, diameter - 90 mm), manufactured by NSC IM. Electrometer - UNIDOS Webline, REF T10021, S/N 000999.
Description of calibration setup:	Direct measurement method. Air kerma - reference value. Charge - for the ionization chamber HS-01. Measurement of temperature and pressure.
Picture of the calibration setup (UGV-1): 	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_{air,ref} \cdot h_K^*(10)}{Q_{user} \cdot k_{Tp}}; \quad R_{ref} = R_{user}$.
Calibration was performed by:	Andrei Orobinskyi, PhD, Chief of laboratory.

NSC-IM

Calibration date/period:	01.06.; 07.06.; 08.06.; 15.06.; 30.06; 02.07.2021
Radiation quality:	S-Co

Method of determination of *H**(10):	Reference instrument is calibrated in terms of air kerma and conversion coefficient is used.
Conversion factor value and source (if applicable):	Value from ISO 4037-3:1999.
Description of the equipment used for calibration:	National standard of Ukraine. Equipment for gamma radiation UGV-1 (collimator: length - 150 mm, diameter - 90 mm), manufactured by NSC IM. Electrometer - UNIDOS Webline, REF T10021, S/N 000999.
Description of calibration setup:	Direct measurement method. Air kerma - reference value. Charge - for the ionization chamber HS-01. Measurement of temperature and pressure.
Picture of the calibration setup (UGV-1): **see S-Cs**	
Determination of calibration coefficients (list all used corrections):	$N_H = \frac{K_{air,ref} \cdot h_K^*(10)}{Q_{user} \cdot k_{Tp}}; \quad R_{ref} = R_{user}$.
Calibration was performed by:	Andrei Orobinskyi, PhD, Chief of laboratory.